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THREE PARSONS STEAM TURBINES of 500 HP. each are about to be built by the Westinghouse Machine Co., East Pittsburg, Pa., for the Westinghouse Air Brake Co., Wilmerding, Pa., to replace ordinary steam engines. Each turbine will drive a 300 K-W. generator, furnishing current for electric lighting and for driving the Tesla motors used in the Air Brake Co.'s shops. The Machine Co. is also building a 2,500 HP. turbine for the United Electric Light & Power Co., of New York city, the first of an order of five of the same size. These will be the largest steam turbines ever constructed. They are to be installed in the new station at 28th St. and East River. Each turbine will be used to drive a 1,500 K-W. multiphase generator. The five engines and generators, aggregating 12,500 HP. can be placed in about half the space now occupied by eight vertical Westinghouse engines of 1,200 HP. each, each with Westinghouse generators, now in the 28th St. station. The Parsons turbine has been used in England for several years, giving excellent results as to economy. One of the advantages it offers is that the water of condensation may be safely returned to the boiler, as no oil is used in the engine.

A COMBINATION TO CONTROL ELECTRICAL plants in the city of New York is reported as formed, with Wm. C. Whitney, R. P. Flower, P. O. B. Widener, W. L. Elkins and A. N. Brady as members. This trust is in reality the New York Gas and Electric Light, Heat and Power Co., incorporated at Albany early in October with $25,000,000 capital. Mr. John D. Crimmins is the authority for saying that this company has already secured the Mount Morris Electric Co., with independent subways and a franchise for lighting the entire island of Manhattan; the Manhattan and the Edison Electric Illuminating Cos. The only important company outside is the Westinghouse Electric Co., with its franchise for furnishing heat, light and power. The Empire Subway Co., principally owned by the Bell Telephone Co., has also been secured. But the real extent of the operations of Mr. Whitney and his associates, and their ultimate purpose, are as yet practically unknown, as Mr. Crimmins is no longer associated with the deal, and Mr. Whitney insists that the details are exaggerated, and the Metropolitan Traction Co. simply seeks to sell its surplus power. The purchase of the Manhattan and Edison companies is not confirmed.

THE EXTENSION OF STREET RAILWAY FRANchises in Chicago for a period of 50 years is asked for by the Chicago street railway companies, and an ordinance extending all their franchises for that period has been presented to the City Council by representatives of the leading companies. It provides for payment to the city of a certain percentage of the gross receipts, to be based upon the earnings per mile, as follows: 0.5% for lines earning $7,500 to $10,000 per mile; 1% up to $12,500, 1½% to $15,000, 2% to $20,000, and 3% for all above $20,000 per mile. It also provides means for ascertaining the amounts of the earnings, sets the time for payment, and establishes a 5 ct. fare during the first 20 years of the extended franchise. The mayor is opposed to the ordinance, considering 50 years too long a term, and that the franchises should only be extended for 20 years. He also favors higher rates of compensation, and requirements for improved service on the part of the companies. A mass-meeting was held on Dec. 11 to protest against the extension of the franchises, and the municipal ownership of the street railway lines was favored. On the following day it is reported that the council "indefinitely sidetracked" the ordinances by a vote of 38 to 25.

A CONTRACT FOR A NEW WATER SUPPLY for Jersey City has been awarded by the Street and Water Commissioners to Mr. Patrick H. Flynn, of 189 Montague St., Brooklyn. It is expected that the Board of Finance and the Mayor will approve the award. Mr. Flynn is to build works for the delivery of water by gravity to the present distribution system, the city to buy water by the million gallons, unless it decides to purchase the works. The latter plan it cannot adopt for the present, owing to its financial condition. The supply will be from the Rockaway River. The price per million gallons will be as follows: For the first 25,000,000 gallons a day, $36; for the next two 5,000,000 gallons, $34 and $32, respectively; for the next 10,000,000 gallons, $24; for all above 45,000,000 gallons per day, up to the limit of the possible capacity of the works, or 70,000,000 gallons, $20. This is on an average of $31.40 per 1,000,000 gallons for 50,000,000 gallons a day, and of $28 for 70,000,000 gallons a day. In case the city elects to buy the works, the price for a plant developed to a capacity of 50,000,000 gallons a day, but with a drainage area able to supply 70,000,000 gallons, would be $7,595,000, if the works were bought at completion, and $7,995,000 if bought at the end of 5, 10 or 15 years after completion. Works developed to supply 70,000,000 gallons a day would cost the city $8,745,000, or $9,245,000, respectively, in accordance with the dates of purchase mentioned above. It is reported that Mr. Flynn has made arrangements with the East Jersey Water Co., and those associated with it, for the necessary water rights in the Rockaway drainage area.

A COMBINATION ARCH AND GRAVITY MASONRY dam is being built near Johannesburg, South Africa, with Mr. Wm. Ham. Hall, M. Am. Soc. C. E., of San Francisco, as consulting engineer. The extreme height of the structure, from the foundation to the crest, is about 120 ft., and the maximum depth of water will be about 90 ft. The arched portion of the dam will be 340 ft. long, with a radius of 275 at the crest. The thickness of the arched portion will be 36½ ft. at the top of the foundation, with an offset of 3½ ft. 20 ft. above, and a batter to 7 ft. at a point just below the coping. The valley at the dam site is some 600 ft. across. The foundation will be of concrete and old rails, and the superstructure of uncoursed rubble. A Lidgerwood cableway is used for constructing the dam. The water impounded by the dam will be used for mining purposes. The work is being carried out by the Vierfontein Water Syndicate, which is controlled by the Consolidated Gold Fields, Messrs. H. Eckstein and others.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred Dec. 7 on the Clarion River R. R., near Portland Mills, Pa., resulting in the death of three persons and in the injury of three others. A freight train was cut in two to descend a steep grade, and while the first section was descending the rear section started down the grade and ran into the first section, killing a brakeman. An engine and crew of five men was ordered out to clear the track. On the return trip it jumped the track, rolled down an embankment, and so seriously injured two men that they died within a few minutes.

THE FALL OF A THEATRE ROOF in Detroit, Mich., on Nov. 5, mentioned in Engineering News of Nov. 10, resulting in the death of 12 persons, was due, according to the verdict of the Coroner's jury

to the collapse of the trusses of roof of said building, caused by said trusses and steel roof construction not being of sufficient strength for the weight they were carrying. We find that the responsibility for said collapse rests upon the firm of John Scott & Co., architects of said building.

THE FALL OF A SECTION OF STEAM PIPE in the United States Electric Lighting Co.'s power station in Washington, D. C., on the night of Dec. 8, caused the extinguishment of every light operated by the station. According to press reports, one of the steam pipes burst and a large section of the pipe fell striking a corner of the switchboard in such a way that all of the station lights were extinguished. To properly repair the damage it was necessary to cut off all the circuits.

THE U. S. BATTLESHIP "MASSACHUSETTS," on leaving the Brooklyn Navy Yard on Dec. 11, struck on a sunken obstruction near Diamond Reef, and sprung a leak in several of her forward compartments. The leaks were quickly stopped by cement, and she will be put into the dock at the yard for permanent repairs. The divers report later that the keel is twisted and buckled at 17 places over a length of 240 ft.

A LARGE GAS HOLDER WAS WRECKED at Baltimore, in a high wind on Dec. 4. The tank, which is one of a row, was partially overthrown against the stone coping containing its water bed. The weight crushed the supporting columns on the leeward side of the tank breaking each into several pieces. The contact with the edge of the coping tore several rents in the shell of the tank, and it is supposed that sparks caused by the friction of the metal against the stone ignited the gas, which escaped through these holes. The contents, amounting to about 300,000 cu. ft., caught fire a few seconds after the gas began to escape, and the portion already in the air exploded, bending the top and sides of the tank. The heat of the flames warped and blistered the metal on the outside for a distance of about 75 ft. The reservoir was 97 ft. in diameter, 47 ft. high, and supported by eight columns of ¾-in. cast iron internally fastened by flanges, reinforced by columns of lattice work. The tank had been in use for 28 years.

THE FAILURE OF A LARGE GAS TANK belonging to the Consolidated Gas Co., of New York, N. Y., and located on the block bounded by 1st Ave., Ave. A, 20th St. and 21st St., in that city, occurred on the evening of Dec. 13, killing and injuring a number of people and destroying considerable surrounding property. According to the best available information the tank, which had just been completed, was being tested when the failure occurred. The holder was 174 ft. in diameter, made up of four sections which telescoped into each other, and which, when fully extended, brought the top of the holder 160 ft. above the bottom of the retaining tank. The retaining tank was 178 ft. in diameter and was a steel cylinder extending 17 ft. below the surface of the ground and 25 ft. above the surface. The retaining tank altogether was thus 42 ft. deep, and it was built of steel plates decreasing in thickness from 1½ ins. at the bottom to 1 in. at the top. To stiffen the tank there were a row of metal buttresses around its outer circumference and a circular lattice girder at the top. There were the usual lattice column girders, pulleys, counterweights, etc., for raising and lowering the holder. The tank and holder were complete, except for minor details, and, as stated above, were being tested preparatory to putting them into use. In order to make the test it was necessary first to fill the containing tank with water and then pump air into the holder until it rose section by section to its full height. According to the best reports of the failure which are available the containing tank was just filled with water when the accident happened. An examination of the ruins shows the shell of the retaining tank torn open vertically in several places, but on the north side the rupture was complete and the ruins of the holder had been thrown or carried through the break and were piled high across 21st St. The failure resulted in the gas being shut off from all consumers supplied by the plant of which the destroyed tank was to have formed a part. Among those who suffered most inconvenience from the shutting off of the gas were the number of daily papers and printing offices which used the gas to heat the type metal used in their linotype machines. The office in which type for Engineering News is set was among the sufferers, which accounts for the delay which some of its subscribers may experience in receiving their copies of this issue. A more complete description of the accident will be given in these columns next week.

BREAKS IN WATER MAINS at Philadelphia and at St. Louis are reported as having occurred within the past few days. The mains in each case were 36 ins. in diameter.

A BREAK IN A 48-IN. WATER MAIN occurred early Sunday morning, Dec. 11, in the eastern part of Brooklyn. A hole some 50 to 75 ft. square and 15 ft. deep was washed out by the escaping water; several buildings were undermined, numerous cellars were flooded, sidewalks and streets were damaged, and sand was deposited here, there and everywhere. A section of a small egg-shaped sewer, and of a pipe sewer, as well as gas mains and small water mains, were washed out, and the double track of the electric railway in the street was left without visible means of support for a hundred feet. The broken pipe was one length of a 48-in. supplementary force main laid from the Ridgewood pumping station about seven years ago. It is said that it was under from 30 to 40 lbs. pressure. The break is attributed to a defective casting.

A 6,000,000-GALLON MECHANICAL FILTER PLANT, at Norfolk, Va., is to be built by the New York Filter Mfg. Co., of New York city. The contract was recently awarded the company at $55,000. Mr. J. Thomas Peele is registrar of the Norfolk water-works. At Holyoke, Mass., Mr. James L. Tighe, Engineer of the water-works, has been instructed by the water commissioners to prepare plans for slow sand filtration of the water from the Whiting St. reservoir, which furnishes about one-third of the supply of the city. The estimated cost of the filter beds is $25,000. Mr. Tighe thinks work will be started next April. At West Superior, Wis., the water company is investigating filtration, and has consulted with Mr. Allen Hazen, M. Am. Soc. C. E., of New York city. Mr. W. H. Winslow is secretary of the company.

THE JUNGFRAU ELECTRIC RAILWAY.*

Swiss mountain railways are in a general way so well known that the suggestion of a description of another is apt to arouse little interest. However, the mountain road now being constructed into the very heart of the "Jungfrau" of Switzerland cannot fail to interest, owing to the novelty and boldness of the scheme.

The Jungfrau is one of the highest of the Swiss Alps, and is the highest of the group of three neighboring peaks, Eiger, Moench and Jungfrau. Its snow-capped summit, standing 13,670 ft. above the sea level, affords a magnificent view of the impressive mountain scenery, and has ever been a favorite climb among those sturdy enough to scale its rugged sides. The illustration, Fig. 1 affords an excellent idea of the grandeur and sublime beauty of this mountain mass.

To make accessible to all visitors the magnificent panorama of snow-capped mountains and glistening glaciers which has heretofore been only possible to hardy mountain climbers, is the project which is now being carried into effect through the untiring energy of Herr Guyer Zeller, president of the Jungfrau Railway Commission. It is, of course, out of the question to build a railway on the surface of the mountain, which is on a succession of high precipices and deep ravines, and where avalanches occur almost daily at certain seasons of the year. The idea, from the inception of the scheme, has been to tunnel the mountain not far below its surface, and finally reach a point at the base of the highest peak, from which point a vertical shaft would run straight up to the summit, which is about 7,000 ft. above Little Scheidegg, at the base of the mountain, where the mountain railway will begin. This station, nestling at the foot of the great Eiger peak, is on the Wengern Alps Ry., a rack railway, which, by means of a powerful steam locomotive, climbs up from Lauterbrunnen, 4½ miles distant, to the crest of the lower ridge, which is capped by Little Scheidegg (A, Fig. 2), with an elevation of 6,670 ft. above sea level, and then descends on the other side to Grindelwald. The new road, as already mentioned, starts from this station, and, after climbing along the base of the Eiger for a distance of 1.2 miles on a 10% grade, rapidly increasing to 20%, until it reaches the Eiger Glacier station (B), 840 ft. above the starting point. It then plunges into the hard rock of the mountain, through which it burrows for 0.9 mile on a 25% grade to the second station, Eiger Wand (C), 9,200 ft. above sea level. Here the tunnels runs close enough to the face of a precipice to permit windows to be cut through. Continuing the road climbs up still on a 25% grade, and in tunnel until it emerges into the open air at Eismeer Station (D), 1.5 miles further on and 10,360 ft. above sea level. The next section is on a 6¼% gradient, and up this the tunnel continues the climb for 2.6 miles to Jungfraujoch, (E) the fourth station, 850 ft. above the last, and 11,210 ft. above the sea. From this station, for a distance of 1.7 miles, there is a steady ascent on a 25% gradient to the foot of the elevator shaft (F), 240 ft. below the highest point of the Jungfrau. At the top of the elevator shaft will be erected a suitable sheltered observatory provided with everything necessary for the comfort of visitors. Table I. gives in a compact form the distances and elevations of stations and the various grades.

With the exception of the Jungfraujoch, the stations will be enlargements of the tunnel in the solid rock, affording visitors an opportunity to look out over the mountain scenery only from windows and balconies cut through the rock faces. It is expected that Jungfraujoch will be a point of departure for sledging or pedestrian parties. The subterranean stations will be equipped with hotel conveniences so that passengers desiring to, may stop off for a short rest or all night if desired. About three-quarters of the total distance, some 6.7 miles, must be cut through a firm limestone, which, if dependence can be placed upon the smooth, firm exposed slopes, which show no disintegration, will need no lining. The remainder will be in alternate layers of gneiss and limestone, requiring a masonry lining. It is the intention of the engineers to line this section with the rock blasted in tunneling, laid in Portland cement. This cement they expect to work at temperatures as low as — 6° C (+ 21.2° F.). The water for mixing will be carried into the tunnel in the form of ice, which will be melted when needed by electric heaters, and kept in a liquid form by the addition of a small quantity of salt. The tunnel is 14 sq. meters (150.6 sq. ft.) in section, and in its construction a new explosive compound, "Lithotrit," is employed, because it is free

Eiger. Moench. Jungfrau.

FIG. 1.—VIEW OF THE JUNGFRAU GROUP. FROM A PHOTOGRAPH TAKEN NEAR LITTLE SCHEIDEGG STATION.

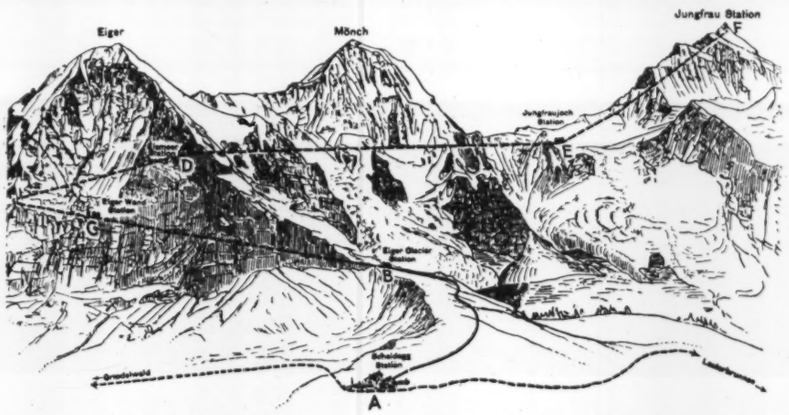

FIG. 2.—SKETCH OF THE JUNGFRAU GROUP, SHOWING ROUTE OF TUNNEL AND LOCATION OF STATIONS.

TABLE I.—Distance Between Stations, Elevations, and Gradients of the Jungfrau Railway.

No.	Station.	Height, ft. Station to station.	Height, ft. Above sea level.	Distance, miles. Statn to station.	Distance, miles. From start.	Maximum gradient, %.
A	Little Scheidegg	0	6,770	0	0	0
B	Eiger Glacier	840	7,610	1.2	1.2	25
C	Eiger Wand	1,610	9,220	0.9	2.1	25
D	Eismeer	1,140	10,360	1.5	3.6	25
E	Jungfraujoch	850	11,210	2.6	6.2	6¼
F	Elevator	2,220	13,430	1.7	7.9	25
	Summit Jungfrau	240	13,670	...	7.9	vert.

*Abstracted from the "Electrician" (London), for Sept. 23, 1898, with additional information from "Centralblatt der Bauverwaltung," for Oct. 30, 1897.

from noxious gases and is not affected by cold. Dynamite is, however, used in open work, and for such work is thawed out by electric heaters and wrapped in non-conducting materials previous to inserting in the drill holes.

At the present time about 1,500 ft. out of the total of some 45,000 ft. have been excavated, and tunneling is progressing steadily, the intention being to continue summer and winter until com-

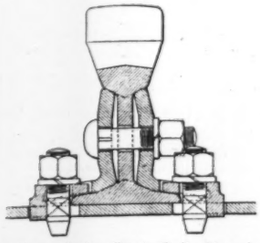

Fig. 3.—Section of the Rack Rail, Showing Method of Splicing and Securing Rack to Ties.

pletion, the time for which is set at 1904. The workmen, mostly Italian laborers, are housed in barracks built on the mountain side. All the drilling, lighting and hauling is done by electricity and a considerable plant is required to furnish the necessary current. Two types of electric drills are being used, a rotary, manufactured by the Oerlikon Co., which is operated by a 3 HP. motor and feeds 0.08 ins. per revolution of the cutter, and the usual percussion form, built by the Union Elektricitats Gesellshaft, making 400 4¾-in. strokes per minute.

The temporary power plant furnishing current for construction work is located at Lauterbrunnen, where ample water power to drive a 1,000 HP. generator is obtained from the White Lutschine River. This generator, manufactured by the Oerlikon Co., furnishes three-phase current at 7,000 volts with a periodicity of 38 for transmission up the valley to Little Scheidegg and the Eiger Glacier, where the voltage is dropped by means of static transformers to the working pressure of 500 volts. The transmission line is 4½ miles long, in which distance it ascends 4,250 ft. It is composed of 3 bare hard-drawn copper conductors 7.5 mm. in diameter, supported upon large earthenware triple-petticoat insulators 4½ ins. in diameter and about 7 ins. high. Heavy wooden poles 33 ft. long are frequently placed

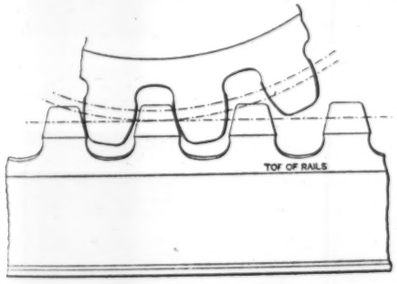

Fig. 4.—Form of Teeth of Rack Rail and Driving Gears.

and upon these are mounted galvanized iron brackets. As a precaution, wherever the lines cross footpaths a circular guard net is suspended, almost surrounding the transmission wires. A telephone circuit is also mounted upon the same poles and the conductors of this circuit have to be crossed frequently to counteract the great inductive effect of the high tension current on the transmission circuit.

The substations are substantial stone structures intended to withstand the extremely severe weather of that region, and each contains two 200 K-W. Oerlikon static step down transformers, dropping the current from 7,000 volts to 500, at which voltage it is supplied to the secondary or working feeders. These are 9 mm. hard drawn copper conductors, supported in the same manner as the transmission lines. During construction a rotary converter is employed to supply direct current for rock drills and other machinery. The intention is to install in suitably protected rooms, spaced about every 3,280 ft., static transformers, which will furnish power for mining as the work progresses, and will eventually feed the line wires from which the locomotives will take current. A separate set of transformers will furnish the current for the elevator running up the vertical shaft.

The permanent power plant at Lauterbrunnen, when completed, will be operated by turbines taking water, as in the present plant, from the White Lutschine River. About 1,320 gallons per minute will be required, under a head of 115 ft., which is brought to the power house from just below the Staubbach Water Falls by a steel pipe line 5 ft.

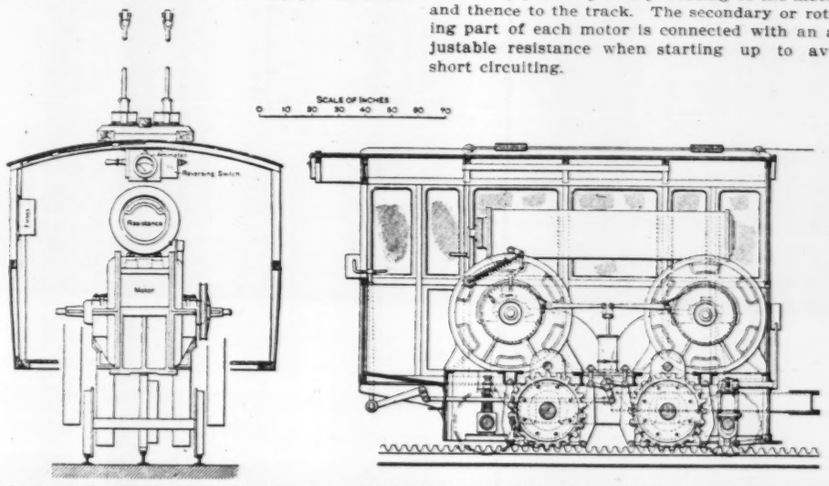

FIG. 5.—ELEVATION AND SECTION OF JUNGFRAU ELECTRIC LOCOMOTIVE, SHOWING TRUCK FRAMING, MOTORS, GEARS AND THE DOUBLE TROLLEY.

11 ins. in diameter and 4,500 ft. long. For about half this distance the slope of the pipe is only about 0.3%, and this portion has a thickness of 0.197 ins., each section being 19 ft. 8 ins. long. The remainder of the line has a decided grade and varies in thickness from 0.236 ins. to 0.276 ins. At the junction of the two sections, just mentioned, is inserted an air cushion column, its duty being to relieve water hammer on the pipe.

The turbines are of the twin Girard type, made by J. J. Rieter & Co. The speed is regulated by Rieter automatic governors belted directly to the turbine shaft. The three-phase generators are manufactured by the Oerlikon Co., and are directly connected to the turbines.

The track and roadbed of the railway will be constructed in the most substantial manner. The rails are laid to a 3 ft. 3⅜-in. gage. They are of the usual Vignoles section and weigh 40 lbs. per yd. Steel channel ties, spaced 3 ft. 3 in. c. to c. are used, and to these are bolted the rack rail, Figs. 3 and 4, which is rolled solid, like the ordinary rail, in lengths of 11½ ft. The teeth are afterwards cut cold. This rail weighs 68½ lbs. per yd. Fig. 3 shows the method of securing the rack to the cross ties and how the sections are spliced. On the road from Eismeer to Jungfraujoch, where the grade is only 6¼%, no rack will be used. On all other sections, however, the rack will be necessary. As the rails are used to carry current, forming one branch of the three-wire system, the tracks are carefully bonded, two "Chicago" copper bonds of 7 mm. section being used for each rail joint, and every 165 ft. the rails are cross bonded with a 8 mm. copper wire.

The trolley wires, two in number, are supported side by side by hanging insulators and span wires strung between wooden poles, on open portions of the line, and by well insulated ceiling hangers inside the tunnel.

The electric locomotives, as will be seen in Fig. 5, consist of a heavy frame built up of channels and I-beams, mounted upon two pairs of wheels, and upon this truck are placed two large three-phase induction motors, which through separate sets of double reduction gears operate the heavy gears meshing into the rack rail. In addition, the whole is covered by a suitable car body to support the four trolley poles, as well as to protect the motors, controller and instruments. These motors range from 125 to 150 brake HP. and run at 760 revolutions per minute on the 500 volt circuit. They weigh 5,200 lbs. each, while the complete locomotive weighs 13 tons.

Fig. 5 shows the arrangement of motors, controller, gearing and braking apparatus of the first locomotive constructed, while Fig. 6 indicates clearly the method of wiring up from trolley to track. For purposes of explanation we may assume that the line current enters the double trolley 1, 2 and 1a, 2a and passes down through a reversing switch and a set of multiple fuses to the stationary part or primary winding of the motors, and thence to the track. The secondary or rotating part of each motor is connected with an adjustable resistance when starting up to avoid short circuiting.

The matter of braking and control of speed is one of considerable importance about which the "Electrician" says:

One of the great advantages of the three-phase system, aside from cheapness of transmission, lies in the simple automatic breaking action of the induction motor. When the locomotive is going down hill the stator or primary of the motor cannot greatly exceed the speed of synchronism. From Fig. 6 it will be seen that the motors are merely controlled by a reversing switch (through which the stator is connected to the line), and the usual rheostat in the rotor

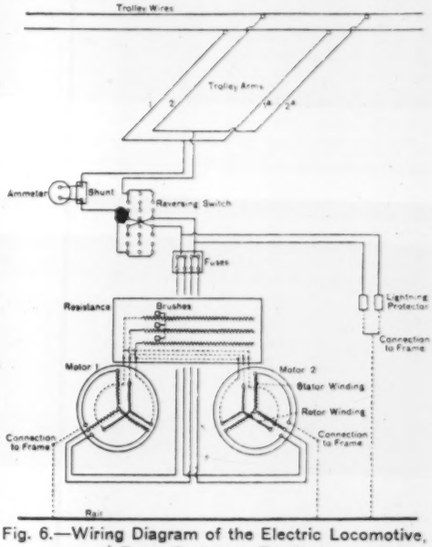

Fig. 6.—Wiring Diagram of the Electric Locomotive, From Trolley to Track.

or armature circuit to avoid starting the armature on a short circuit. The locomotive is fitted with three absolutely independent brakes. The first is an automatic one, electrically controlled by means of a centrifugal governor, which, when the speed exceeds a certain maximum, switches the current off the motors, at the same time applying a band brake. A dash-pot prevents slight momentary increases in speed from putting the brake in action. This brake can also be applied by the guard in the passenger car, where a suitable switch is provided. The second brake is a hand one, which applies bronze shoes to a wheel on the driving axle, and the third is an emergency brake, arranged to grip the rack rail. It can be applied by either the engineman or the guard in the passenger car.

The car is pushed ahead of the locomotive and has a capacity for 40 passengers. At times of heavy traffic two cars

will be used per train. The train is lighted by 6 incandescent lamps on the locomotive, two in series on each phase, and 15 on each car, arranged five in series on each phase.

The estimates upon which the project was financed allowed a traffic of only 10,000 passengers per year to the top of the Jungfrau, although fully 160,000 persons visited Interlaken in the season of 1895, and the rate of increase of visitors to Interlaken is about 30% every 5 years.

At the time the franchise for the road was given the maximum round trip rate was limited to $8.68; but it is understood that the company contemplates a much lower rate ($6.75), with a schedule for the intermediate stations based upon this.

Using this basis and including the income from all sources, the total annual receipts are placed at about $139,350. The estimated operating expenses, reserve fund and interest on $1,200,000 at 4%, amount to about $86,850. The surplus amount, it will be seen, is equivalent to nearly 7% on $800,000 capital. The entire cost of the road, including construction and equipment, is estimated at $1,930,000.

IMPROVEMENTS OF THE WATER-WORKS OF COUNCIL GROVE, KAN.

By L. L. Tribus,* M. Am. Soc. C. E.

During 1897-8 certain improvements to the water-works of Council Grove, Kan., have been under the writer's direction. Those not familiar with the action and condition of rivers in alluvial regions, can scarely appreciate the peculiar difficulties attending their use for public water supply systems. The larger cities of the West have scarcely solved the problem; certainly the smaller ones cannot be expected to have done so.

The little city of Council Grove, in Central Kansas (under 3,000 population), possesses eminently all the disadvantages of such a source of supply, and is without means to experiment on adequate scale for improvements. The surrounding country consists of rolling prairie land, with a range of elevation of about 100 ft., scantily timbered in spots. The country is intersected at frequent intervals by steep-banked gullies, filled in rainy times by flashy streams, that run from 10 to 30 ft. in depth of water, and a soil of fine blackish loam on limestone or other rock substratum.

The hot winds of summer parch the land; sudden rainstorms, often coming with great violence, wash the powdered soil into the streams, turning them into literally mud rivers; the lack of timber districts to hold back the water and the shallowness of the soil ensures the storm waters reaching the streams in very short order, causing floods of a violence almost unknown in Eastern streams, a rise of 5 to 25 ft. in ten hours being of not infrequent occurrence. Passing between banks of alluvial soil, these floods exercise their own taste in cutting and changing the course of the rivers with little warning or chance for resistance. Deflection cribs are used somewhat, but are of rather problematic value. At the same time these floods are the life of the land; by overflowing the bottoms they deposit much fertilizing material and enable the raising of heavy crops of corn and grain; their abatement being almost as rapid as the rise, relieves the land from "drowning." These general conditions are typical of thousands of square miles of Western lands; eminently so of Council Grove and vicinity.

An engineer would not select the Neosho River, such a one as the above, as the source of supply of a municipal water system unless obliged so to do. The soil is largely clay and loam, and shallow at that. The underlying rock of limestone, not freely water bearing, makes driven or bored wells very scanty in yield of water, usually of very hard quality, unsuited for domestic and manufacturing purposes. No lakes or other sources are available, hence the best had to be made of undesirable conditions.

The city of Council Grove has the same early history of most such prairie towns, built without special reason or necessity, but it is there, and has passed through the throes of municipal development to a stage of permanence and moderate prosperity. Some ten years or so ago, a contract was made on the franchise plan with a private company, for the construction and maintenance of a public water system, directing the company to adopt the Neosho River, as the source of supply. A large brick intake well in the river bank was built, with influent pipe from a deep pool in the river's bed. From this well, the pumps, placed in a neat little brick station, situated some 100 ft. back on higher ground, lifted the water and delivered it at a wrought-iron stand-pipe 20 ft. in diameter by 75 ft. in height, on an eminence nearby, from whence by gravity the city was supplied.

For the period until July, 1897, such water as was used consisted of fairly soft river water, mixed with varying proportions of silt, ranging from a light semi-transparent brown to a deep chocolate color. No special effort was made by the company to improve the condition of the water nor was objection raised by the citizens to its use. Street flushing and sprinkling, boiler use and fire service, naturally made up most of the consumption; rain water tanks and cisterns inadequately serving for domestic needs. In the above month of July, 1897, it began to be realized that modern methods properly adapted could give at least an improvement in supply, and the company, though far from prosperous, undertook to reconstruct the plant, recently completing the changes planned by the writer, its consulting engineer.

A peculiarity of the Neosho River, and one to be remembered, is, that during most of the year it is simply a succession of pools from one-fourth mile to one mile in length, and from 3 to 10 or 12 ft. in depth. The riffles, or low natural dams separating the pools, are composed of a sort of cemented gravel, quite water-tight. When the pool nearest the pumping station becomes too low, a narrow trench is dug through the next riffle above, and its waters are drawn down for use.

Last autumn (1897) this supply, even, came perilously near to being exhausted, but usually storms have been of sufficient frequency to scour out and fill up the pools with fresh water. At best, however, the water was more or less filled with matter in suspension; some of the time becoming offensive. The consumption was about 100,000 gallons per day on the average, the Missouri Pacific Railroad using about one-half the total for its locomotive boilers.

The plans for improving the water plant as carried out, consisted, first, in raising the riffle below the pumping station about 5 ft., making of it a good highway crossing, though submerged at flood times; both of these conditions are shown by the views, Figs. 1 and 2, respectively. This gives additional storage of some 5,000,000 or 6,000,000 gallons, giving opportunity for greater sedimentation, thus improving the quality, or rather decreasing the chance of spoiling, by the increased depth of the reservoir.

A solid masonry dam would have been too expensive, but as rock-bottom was attainable for foundation, a rubble masonry core wall, 5 ft. thick at the base and 3 ft. at the top, was constructed, finished off with a heavy coping, alternate blocks being depressed some 8 ins. to make waterways for the dry weather flow, and the higher stones affording footing for pedestrians. Upstream from this wall was deposited a heavy clay and gravel fill bank, 22 ft. wide on top, with an upstream slope of about 5 to 1. Sixteen feet of the top was paved with stone, edged on the upstream side with a deep-set curve, the downstream side abutting against the core wall. The downstream slope, below the heart wall, was paved with heavy stone blocks, on the same clay and gravel fill of which the rest of the dam was built.

The general idea and hope, based on a study of the river's action, was that floods would pass over in a "roll" without scouring action, the flat slopes and broad crest deflecting rather than checking the current. Events have thus far justified the belief, for a number of floods have already passed over the dam without causing any special damage, and even depositing some additional gravel on the crest.

A 24-in. cast-iron pipe sluice serves for a low water drain when needed. The pool enlarged by this dam extends about 1½ miles upstream to near the foot of an old timber crib dam (also controlled by the Water Co.), which forms a second storage reservoir. At present this is in a very dilapidated condition, but it is the intention to later put it in substantial shape again.

The second main change of system was the installation of a filtration plant. The filter erected

FIG. 1.—HIGHWAY DAM ACROSS THE NEOSHO RIVER FOR THE WATER-WORKS OF COUNCIL GROVE, KAN.
L. L. Tribus, M. Am. Soc. C. E., Consulting Engineer.

FIG. 2.—COUNCIL GROVE HIGHWAY DAM SUBMERGED BY FLOOD.

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by the New York Filter Manufacturing Co. consists of a wrought-iron closed tank, 10 ft. in diameter, filled with sand, gravel, coke and broken stone, housed in a neat brick addition to the pumping station. Water from the pumps is forced through this closed tank into the main to the stand-pipe; a small volume of water under the same pressure passing through a by-pass and small tank filled with lumps of sulphate of alumina, and in turn joining the main volume of water before reaching the filter. Enough of the alum is taken up to form a flocculent precipitate, which assists the upper layers of the sand in entangling and retaining matters that are in suspension.

For ordinary stages of the river, this process yields clear water. For specially muddy stages there is admitted to the suction well some lime water, and just before entering the pumps, a strong alum solution. This, it is hoped will, with a slower rate of filtration, answer for all conditions, though as yet the experiments have not been of sufficient duration to demonstrate to a certainty. The reversal of current in the filter once in one or two hours, for a few minutes at a time, suffices to cleanse the filter, and keep it in good operating condition, without a very large waste of filtered water (used for the washing).

The building added to the pump-house is arranged for two mechanical filters of 250,000 gallons capacity per 24 hours each, though but one is as yet installed. In the pumping station are also situated the city electric lighting engines, operated by the same steam plant that supplies the pumping engines; so the combined operations

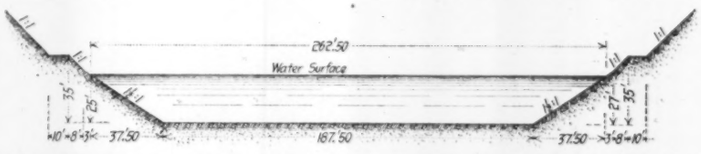

FIG. 1.—CROSS SECTION OF THE ST. LAWRENCE POWER CO.'S WATER POWER CANAL, NEAR MASSENA, N. Y.

can be carried on with reasonable economy—pumping by day and running the dynamo at night. With filtered water the economy in operating the boilers is considerably increased, over the former use of rolly water, all that was then available.

It is not claimed by the water company that the results secured make the plant ideal in any way, but that making the best of poor advantages, the improvements can be called successful, and a very unfortunate supply of water made available for fairly satisfactory use.

METHODS OF WORK ON THE ST. LAWRENCE POWER CO.'S WATER POWER CANAL NEAR MASSENA, N.Y.

(With full-page plate.)

One of the most notable pieces of canal work now in progress in this country is that for the new water-power electric plant which is being built at Massena, N. Y. This canal will be 187½ ft. wide on the bottom, which, with a depth of water of 25 ft., and side slopes of 1 on 1½, will make the width at water level 262½ ft. As will be noticed, this section is greater than that of any other existing canal, and will be exceeded only by that of the Chicago Drainage Canal when this is excavated to its final dimensions of 202 ft. wide on the bottom, with a depth of water of 22 ft. and side slopes of 1 on 1½. Fig. 1 shows a cross-section of the St. Lawrence Power Co.'s canal as it is planned, although it seems probable now that some of the material will actually require flatter slopes in order to stand, and, therefore, that some of the figures which have been adopted will be changed for certain sections of the work at least. The drawing shows only the normal section, which is to be widened out at one end to form an entrance bay, and at the other end into a fore bay. The dimensions of these enlargements are not yet finally determined. Altogether the work will entail the excavation of about 8,000,000 cu. yds. of earth consisting mostly of quite soft clay and clayey loam, although in the two deep cuts and at other isolated points a sort of hardpan or very hard indurated clay filled with boulders of all sizes is encountered. In the power house foundation work there is also considerable rock excavation.

The engravings on our full-page plate and in the text show the methods being employed to excavate these materials. These photographs and drawings and the bulk of the information from which this description has been prepared were collected during a visit made to the work on Nov. 17 and 18 by a member of the editorial staff of Engineering News. For aid in collecting this material we are indebted to Mr. Robert Swan and Mr. J. B. Walker, respectively Vice-President and Assistant Engineer of The T. A. Gillespie Co., of New York, the contractors for the work, and to Mr. Wm. H. Cushman, Resident Engineer, St. Lawrence Construction Co., Massena, N. Y. The entire work is being carried on by The T. A. Gillespie Co., and all the plant described is owned and operated by it.

Historical and General Description.

The Massena water-power electric plant is being built by the St. Lawrence Power Co., of London, England, and English capital is being very largely employed. The actual work of construction, however, is being done by the St. Lawrence Construction Co., of New York, N. Y., which is generally understood to bear the same relation to the St. Lawrence Power Co., as the Cataract Construction Co. did to the Niagara Falls Power Co. Mr. John Bogart, M. Am. Soc. C. E., of New York, is Chief Engineer of the construction company. The St. Lawrence Construction Co. sublet the work first to the Lehigh Construction Co., which began operations in the summer of 1897, and installed considerable plant, a large camp, shops, stables, boarding barracks, etc. No great amount of actual excavation, however, had been done by the company when it assigned on Feb. 15, 1898. Matters which had naturally become somewhat mixed were readjusted, and a new contract was let to The T. A. Gillespie Co., of New York city, on June 15, 1898. This company began work 15 days later, on July 1, and has pushed the excavation rapidly since that time.

The plan contemplated is to divert a portion of the waters of the St. Lawrence River and carry it by a surface canal across a comparatively level plateau to the gorge of the Grasse River, where a fall of 42 ft. can be secured. As shown by Fig. 2, the line of the canal is almost straight southeast.

The Grasse River acts as the tail race discharging the water into the St. Lawrence River again, but further downstream. It is just on the bank of the Grasse River that the power house will be situated, which will be almost a duplicate of the power house of the Hudson River Power Co., at Mechanicsville, N. Y. (Eng. News, Sept. 1, 1898), in everything except size, the Massena plant being about three times larger. Fig. 1, as before stated, is a cross section of the canal prism; Fig. 2 is a sketch map of the line, and Fig. 3 is a profile of the canal showing the progress made in excavation up to Nov. 1, 1898. As will be seen, the canal is about 16,200 ft., or slightly over three miles long.

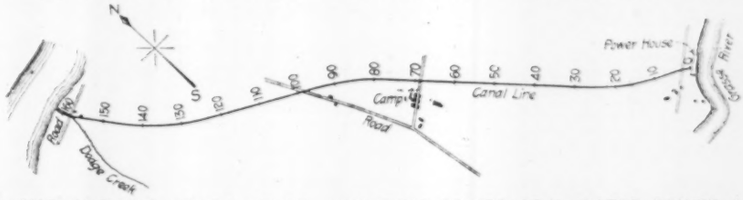

FIG. 2.—MAP SHOWING ROUTE OF ST. LAWRENCE POWER CO.'S WATER POWER CANAL.

Methods of Excavation.

The general method of excavation adopted is to take out the surface lift and the deep cuts to a depth of about 5 ft. above the water surface by some system of dry excavation. According to the preliminary borings this will remove all of the harder material. The remainder of the prism between 5 ft. above the water surface and the bottom of the canal it is proposed to take out in the wet by dredging. Two dredges will work inland from the St. Lawrence River and another is now working west from the low point A on the plateau just above the power house. The two dredges which will start at the St. Lawrence River end are orange-peel hydraulic dredges of the vacuum pump type. These machines will be described fully in a separate article in a future issue and will not be mentioned further here except to state that at the time of the visit made by our representative they had not begun work.

Hydraulic Dredge.—The hydraulic dredge proper in operation near the power house end of the canal is shown at work in Fig. 4. Those of our readers familiar with the hydraulic dredges operated on the Pacific coast (Eng. News, Aug. 4 and 11, 1892), on the Chicago Drainage Canal (Sept. 6, 1894, July 4, Aug. 15, 1895), and in other places will recognize the essential features of the machine illustrated, which was built by the Morris Machine Works, of Baldwinsville, N. Y., for The J. A. Gillespie Co. Briefly described, the dredge hull is 65 ft. long, 30 ft. wide, and 6 ft. deep. At the front is an A-frame carrying the ladder supporting the cutter and suction pipe, and at the rear are the two spuds on which the dredge swings when at work. Between the spuds and A-frame comes the housing for the machinery.

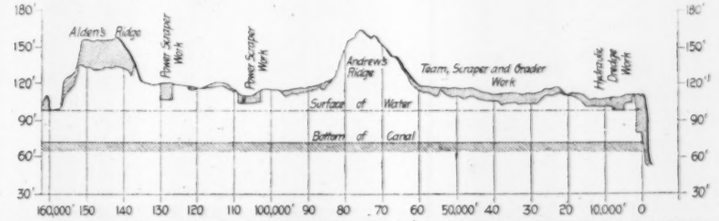

FIG. 3.—PROFILE OF ST. LAWRENCE POWER CO.'S WATER POWER CANAL.
(Shaded area shows progress of excavation on Nov. 1, 1898.)

The dredging pump is one of the Morris Machine Works regular 12-in. high lift centrifugal pumps, directly connected to a 125-HP. compound condensing engine. This pump is designed to operate against a lift of 60 ft., and is very powerful. At a moderate speed of from 150 to 175 revolutions it is stated that a vacuum of from 20 ins. to 25 ins. can be easily maintained on the suction. The pressure on the discharge pipe is usually 18 lbs. running up to 25 lbs. The suction pipe is 12 ins. in diameter and extends to and inside the rotating cutter carried by the ladder. Both the cutter shaft and pipe are coupled so as to allow free movement to the ladder up and down in a vertical plane. The ladder is 45 ft. long. The cutter is

basket-shaped, made of flat iron bars, and resembles quite closely that used on the Vivian dredge employed on the Chicago Drainage Canal (Eng. News, Aug. 15, 1895). A 6¼ × 10-in. six-drum hoisting engine is also arranged on the forward end of the dredge, one end being used for raising and lowering the suction ladder, two for swinging the dredge, by means of the guy lines to the opposite banks of the cut, and two for operating the two stern spuds. This engine also generates the cutter. Progress ahead is made by alternately raising and swinging on these spuds, thus "walking" the dredge forward. Steam is supplied by a locomotive boiler of 125-HP. at 125 lbs. pressure. Control over all of this machinery is had by the operator from the operator's house at the front end of the dredge.

At the time of the visit of our representative the dredge was working in blue clay, and water was being pumped from the Grasse River, 1,700 ft. away, to supply the necessary water for floating and operating it. This material runs about 15% solid from the discharge pipe, and the average output of the dredge has been about 1,000 cu. yds. in two ten-hour shifts. Although ordinarily well diluted with water, it has sometimes happened that the material was fed into the pump so rapidly that the 1,000 ft. of discharge pipe leading to the shore has started to clog up, when simply by increasing the speed of the main pumping engine the clay would be forced out through the end of the pipe in a nearly solid mass which would break off in lengths of 15 ins. to 18 ins. and drop down. This phenomenon is, of course, always of short duration. Perhaps the most peculiar feature of the work, however, is the pumping of the water in which the dredge operates from a source 1,700 ft. away. A 12-in. Worthington pump is employed to do this pumping, and so far a 6-in. discharge pipe has supplied all the water wanted, but a 12-in. pipe is provided for use if needed.

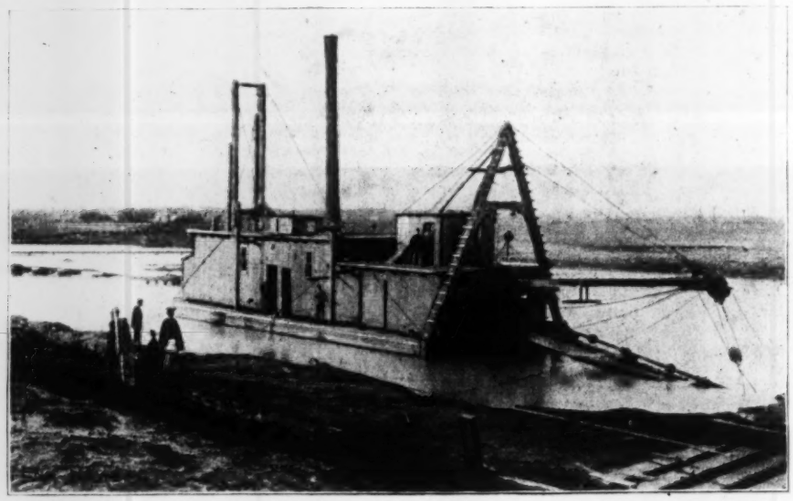

FIG. 4.—HYDRAULIC SUCTION DREDGE WORKING NEAR SOUTH END OF CANAL.

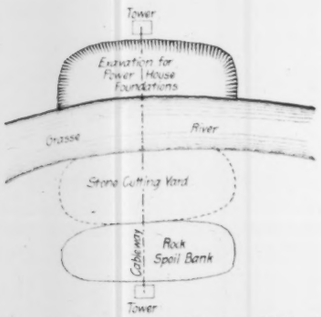

Fig. 7.—Sketch Plan Showing Method of Rock Excavation, Power House Foundations.

The fact that it is regarded justifiable to employ a hydraulic dredge when the water needed for its operation has to be artificially supplied is due in this case to the character of the material. This is a blue clay which is very soft when wet, and which is so located that seepage would be likely always to keep it wet if dry excavation were resorted to. These conditions, unfavorable to dry excavation, are decidedly favorable to successful hydraulic dredge work, which also has here the favoring condition that a neighboring depression affords a convenient discharge basin for the spoil, while allowing the water to drain back to the dredge cut after depositing its load. As stated above, the dredge now handles 50 cu. yds. per hour, and was designed to average 200 cu. yds. per hour. The working crew required consists of the captain, one operator, one engineer, one fireman, and from four to six men to keep the pipe line in order.

Power House Foundations.—The excavation for the power house foundations consists of breaking down the face of the gorge to a level of about 17 ft. below the water level of the Grasse River over an area of about 147 × 633 ft. Figs. 5 and 6 are views of the work, and Fig. 7 is a sketch plan explaining the method of operations. The material is clay down nearly to the water level, and solid rock below, amounting to about 39,000 cu. yds altogether. A steam shovel and a land dredge are the principal machines employed in taking out the soft material, the dredge being worked on the top of the bank, Fig. 5, and the shovel in the cut. Both excavators load into dump cars hauled by locomotives to the spoil banks.

The land dredge, or "orange-peel" excavator, as it is called, is taking out a cut 35 ft. deep in a very homogeneous, cheese-like material. With a 1 cu. yd. bucket the output per ten-hour day averages 600 cu. yds. The total labor cost of operating the machine is stated to be under $20 per day, making it a very cheap and efficient device for handling the material in which it is working.

For the rock excavation a cableway built by the Lidgerwood Mfg. Co., of New York city, is the principal conveying device. As shown by Fig. 7, this cableway spans the excavation, the Grasse River, and a stone yard and spoil bank on the opposite side of the river. Much of the rock being excavated comes out in good enough shape to be used in the foundation masonry, and this is taken across the river by the cableway to the stone cutting yard, where it is cut and stored for future use. The stone in the spoil bank will also be utilized in making concrete, some 30,000 cu. yds. of which will be used in the power house masonry. The view, Fig. 6, shows clearly the condition of work on the power house excavation on Oct. 3, 1898. The Grasse River is shown at the right, or looking down stream, and the line of the cableway may also be seen. This cableway has a span of 1,130 ft.

Team, Scraper and Grader Work.—From the hydraulic dredge work north to Andrews Ridge the top 5 ft. to 8 ft. of loam and clay has been removed by wheel scrapers, power graders and teams. Both the New Era and Western graders have been employed, and their output per ten-hour day has averaged from 600 to 800 cu. yds. Figs. 8 and 9 are views of the scraper and grader work, and they show quite well the nature of the material being handled. Similar methods of excavation were employed north of Andrews Ridge.

Power-Scraper Work.—One of the most notable excavators used on the work is the power scraper designed by Mr. Charles Vivian, and first employed by him on Section 6 of the Chicago Drainage Canal (Eng. News, Aug. 15, 1895). This device showed evidence of its value on the Drainage Canal work, although by the time it had been perfected most of the material in which it was capable of working had been taken out. Its output averaged from 24 to 24½ cu. yds. per hour. Much better work than this has been done by the scrapers on the Massena canal work, they having averaged about 800 cu. yds. per ten-hour day, according to a statement made by the contractors. Figs. 10, 11 and 12 explain pretty clearly the operation and work of the scrapers.

Fig. 10 is a diagram explaining the operation of the scraper. As will be seen, it has three cables attached to it; cable A is used to tip the scraper on end; cable B draws it backward into the pit and cable C hauls it out of the pit when filled. The method of working then is as follows: When the scraper has been drawn into the pit and is in the position shown by Fig. 10, cable A is hauled in sufficiently to stand the scraper on its end, as shown by Fig. 10a. Cable C is then hauled in and the scraper fills as it resumes its original position, and is then hauled out of the pit onto the spoil bank. When here cable A turns the scraper over and drags it a few feet to empty it, after which cable B turns it right side up and drags it back into the pit.

The material in which the scrapers are working is a clayey loam turning into clay toward the bottom of the cut. Fig. 11 shows its nature quite clearly, and also shows the sequence of cuts made as the scraper advances. The ridge of earth left between cuts serves two purposes. First and most important, it permits the scraper to form a path or groove which aids to keep the scraper in line and facilitates its loading; second, when there is much water, as shown in the illustration, it acts as a natural dam to keep the water of one cut from flowing quickly into the succeeding cut. Ultimately, of course, these ridges are broken down and taken out. The scraper, while requiring soft material for its most perfect operation, has its efficiency greatly reduced by the presence of water, which is the reason for keeping the cut as dry as practicable.

Fig. 12 shows the scraper proper with its load; this load of top soil having been taken out in the course of ordinary operation, but being, of course, considerably larger than the general run. The scraper proper, as the illustration shows, is made of steel plate. Its capacity is 3 cu. yds. water measure, and it has a 7-ft. cutting edge. It is planned to lengthen the scraper and raise its back enough to increase the capacity to about double what it is now. A 12¼ × 15-in. engine is used to operate the scraper. The span between towers is 720 ft. Two of the scraper outfits are employed, their work being located as shown by Fig. 3.

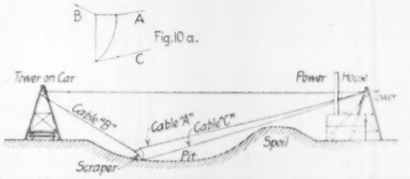

Fig. 10.—Diagram Showing Operation of Power Scraper.

Aldens Ridge Cut.—The deepest cutting which the canal will necessitate is where it passes through Andrews Ridge. Here the depth of excavation to canal bottom will be 92 ft., and the width of the cut at the surface is over 500 ft. The cut at Aldens Ridge is, however, only about 5 ft.

shallower, and, being somewhat longer, it contains more material. As will be seen from the profile, Fig. 3, a pretty good start had been made on the Aldens Ridge cut by Nov. 1. The material is very hard, being an indurated clay filled with boulders, and is peculiar in overlying a softer material, in fact, a soft blue clay, according to the borings made. To take out the hard material six steam shovels were at work at the time of our representative's visit. These shovels were loading into 5 cu. yd. dump cars hauled by locomotives to the spoil banks. Seven and eight cars are used to the train.

Fig. 13 is a view of the work on the top lift of the cut, and shows quite clearly the style of locomotive and cars employed. The shovel shown is one of the Vulcan Iron Works Co.'s special 75-ton shovels designed for handling ore. In the indurated clay and boulders the output of these shovels averages about 1,000 cu. yds. per ten-hour day. A 2½-cu. yd. dipper is used. As stated elsewhere, the steam shovel excavation will be carried down only to within about 5 ft. of water level in the canal, the remainder of the excavation being reserved for the vacuum pump dredge. These, as already stated, will be described fully in a separate article at a future date.

THE PROGRESS OF THE CHICAGO MAIN DRAINAGE CHANNEL.

Aside from difficulties of construction, the prosecution of the Chicago Drainage Canal has been beset with more difficulties during the past year probably than during any other year since work was actually begun. At the very beginning of the year's work legal troubles were encountered, and the litigation, once started, seemed to increase with every new piece of work undertaken. In his report of the canal work for the fiscal year ending Dec. 6, Mr. William Boldenweck, President Board of Trustees, Sanitary District of Chicago, outlines the nature of this litigation, its final decision and the delay produced by it on the work of construction. The following is a brief abstract of President Boldenweck's report:

The last year has not been as prolific of good results as we anticipated. In fact, it was the year of lawsuits for this board and was the banner year in that line since the organization of the district. We had mapped out a great deal of work for the year—work that would have enabled us to complete the great drainage canal during the coming year and thus would have enabled the people of Chicago to have pure and wholesome water to drink in every home. It was only reasonable to expect that we would not meet serious obstacles that would retard this most important work.

We met our first opposition in Joliet. Here the owners of the land we tried to purchase bitterly fought us at every hand. They placed the price of their land so outrageously high that it was impossible even seriously to consider their terms. We finally acquired the land by condemnation at about the prices we had originally offered for them. With the officials of Joliet the fight was quite as bitter. The matter was finally settled only after the board of trustees of the sanitary district has decided to abandon the plan of a large dam, which was to have been constructed diagonally across the river, and which would have left the streets at present grade. Thus was lost what would eventually have proved a great source of revenue to the district and a great benefit to the city of Joliet—the 9,000 HP. water power.

The negotiations with the Illinois & Michigan Canal commissioners had been pending nearly a year. These were taken up again by the trustees of the sanitary district and the commissioners, with the result that a contract was entered into between the two boards which would protect both the interests of the state and those of the sanitary district. Plans in strict compliance with this contract were prepared and the money for the land acquired from the canal board was turned over to its treasurer, who gave his receipt therefor. Almost as soon as this money was paid over an injunction was prayed for against our board by the canal commissioners, which was granted by Judge Hilscher. Our attorneys at once filed affidavits looking to a dissolution of the injunction, which was not granted. However, the case was set for an early hearing, and after a month of preparation and trial the case was practically decided against the sanitary district. This was one of the most tedious and expensive lawsuits in which this district was ever a party.

Under this decision the sanitary district will be compelled to spend several hundred thousand dollars more than was originally contemplated. Further than that, it received no additional benefit, it is delayed in the completion of the great canal and loses a large amount of money by reason of the outlay of more than $27,000,000 by the taxpayers up to this time which is for so much longer a period rendered useless. The matter has been taken up on appeal to the supreme court, where our attorneys will endeavor to get a speedy hearing.

Another great disappointment to the trustees of the sanitary district was the eight-track bridge at Campbell avenue. Our engineering department, after months of hard labor, had designed the plans for a great swing bridge in this locality, upon which from time to time as the work progressed, the railroad engineers made suggestions. When our plans were finished bids were advertised for on this and also upon other designs that would prove acceptable to the railroads interested. When the bids were opened it was found that those upon our plans were the lowest. When the railroad officials looked into the plans and designs, that made by our engineering department was not acceptable to them. Then came the negotiations with the Strobel company and the Scherzer Rolling Life Bridge Co. for the purchase of their designs in order that all the builders of bridges in the country might compete for the construction.

Bids on the two designs, as well as upon others, were received and opened, and a contract finally was awarded to the Scherzer Rolling Lift Bridge Co. The contract was awarded to the Scherzer company not because its bid was the lowest from the standpoint of dollars and cents, but because a majority of our trustees believed it the best bridge, and because the Strobel design had never been tried, and the Scherzer bridge was easier to operate and would cost less to maintain. A contract was entered into and approved, when the C. L. Strobel Co. obtained an injunction from Judge Payne, from which an appeal has been taken to the appellate court.

The conclusion reached in the difficulties which presented themselves at Adams, Van Buren and Taylor Sts., I think, has been eminently wise and for the best interests of the sanitary district. If the land had been condemned, it would have involved, in my opinion, an immense cost, as the land is very valuable, and, furthermore, there would have been large claims for incidental damages by the railroad companies. In the first settlement you, as a board of trustees, entered into an arrangement with the Pennsylvania R. R. Co., at an annual rental for land used under its right of way for a by-pass at $3,000 a year. To the Chicago & Alton R. R. Co., we agreed to pay $116.68 a year for as long a term as the by-passes would be put to the uses of the sanitary district.

A more perplexing problem was the widening of the river at the Northern Pacific bridge at Taylor St. This was because the land that was sought by the sanitary district was of such a character that if condemned and acquired it would destroy a large portion of the railroad company's business, and if a by-pass were built it would still leave the river in no condition to benefit navigation. There had been different committees appointed to confer with the railroad and city officials with the object of enlisting their co-operation in having a bridge constructed at this point that would have no center piers, in the interests of navigation.

Nothing so far as financial aid was concerned was suggested, except by the Northern Pacific R. R. officials, who consented to stand one-fifth of the expense of maintaining the old bridge, while a new one was being built. This company also offered to pay one-fifth of the cost of creating the interlocking system of switches and the changes of the tracks. You finally accepted this offer, and the right to use the Scherzer rolling lift bridge was purchased, in order that as wide a scope of competition might be obtained as was possible. This was made necessary by the decision of Judge Payne, who claimed it was not in accordance with law to advertise for proposals on more than one design or pattern for a bridge.

It is exceedingly gratifying to note the confidence in which the sanitary district securities are held by the public and investors everywhere. This is nowhere made more apparent and manifest than in the sale of our bonds and warrants. The former have been issued bearing 3½% interest, and bringing a premium of 103. 6%. Our warrants issued at 4% are eagerly sought by investors. For the information of the board of trustees, I give the results of the sale of bonds, rates of interest and premiums received from the commencement of the canal work up to the present time:

Date of issue.	Amount.	%	Price.	Sold to
Nov. 1, 1892.	$2,000,000	5	101.51	Blair & Co.
Jan. 1, 1894.	3,000,000	5	101.793	N. W. Harris & Co.
Aug. 1, 1894.	3,000,000	5	100.5707	N. W. Harris & Co.
Feb. 1, 1895.	4,000,000	4½	100.5	N. Y. Life Ins. Co.
Feb. 1, 1896.	800,000	4½	100.6345	First Nat. Bank.
Jan. 15, 1897.	800,000	4½	102.146	Mer. Loan & Tr. Co.
July 1, 1898.	200,000	3½	103.66	Home Sav. Bank.

Our warrants drawn against the tax levy have also decreased in the rate of interest in like proportion as the bonds, and to-day are eagerly sought by investors at the rate of 4% per annum.

Our arrangements with the city of Chicago regarding the construction of conduits and intercepting sewers have been very satisfactory. When these systems are once completed there will be no more pollution of our drinking water. This agreement has not yet been put into the form of a contract, but it is virtually binding by reason of an ordinance passed by the sanitary district trustees and accepted by Chicago city officials.

Under this agreement Chicago is to build all the conduits, intercepting sewers, buildings for pumping stations and properly to equip them with the latest improved machinery, which the sanitary district will operate and maintain forever. This will not work a hardship upon our citizens, as the money is derived from the same source in either case. But the city's resources being necessarily limited in comparison with the amount it actually needs, the sanitary district is enabled to assist in this matter, and does so gladly in the interest of the people of the city of Chicago, especially when it is considered that through the aid of the conduit on 39th St. it receives an increase of at least 375,000 gallons of water per minute.

The construction account shows that the expenses, according to an approximate estimate, have been $22,616,781.36 to date. Of this amount $20,048,525.14 has been audited. Fifty cases against the sanitary district are pending in court. The estimated balance required for the completion of the work July 1, 1900, is $5,225,649.27. The resources of the district to the same date are $6,226,472.92. The net receipts from the day of the organization of the district to Dec. 1 have been $28,077,012.54, and there is a balance of $121,231.88 on hand. (Additional figures of the cost of the canal work will be found in a communication from Chief Engineer Isham Randolph published in our correspondence column this week.—Ed.)

During the coming year the committee on engineering will undoubtedly devote itself to the construction of bridges. Plans and specifications are yet to be considered for the following in Joliet and Chicago: Cass St., Jefferson St., extension of Rock Island bridge in Joliet, extension of Van Buren and Canal St. bridges and Throop St. bridge in Chicago. In the case of the Throop St. bridge, it may not be necessary to build a new structure, but we may be able to utilize the bridge now at Taylor St., where a new bridge is to be constructed of the Scherzer rolling lift bridge type. There will also come up the question of the removal of the Henry and Copperas Creek dams. The law makes it part of the duty of the sanitary district to remove these dams, as well as any other obstructions to the flow of water in either the Illinois or the Des Plaines rivers.

The improvement of the great Calumet region is a matter that should not be lost sight of, as well as the improvement of the north branch of the Chicago River.

There are fifty-four cases pending, in which the sanitary district is a party. It is incumbent upon the committee on judiciary to put forward every effort to bring these cases to speedy trial or settlement before the term of the present board expires.

It was for me a gratification when an opportunity offered itself to open negotiations looking to a settlement of all difficulties between the board of Illinois & Michigan Canal commissioners and the sanitary district. Aside from the contractors clamoring for an opportunity to proceed with their work, the great cost of litigation and the loss of over $3,000 a day for interest on the investment, the gravest feature is the delay in the opening of the channel. It is, therefore, not good policy to be penny wise and pound foolish. We have tested our grievances in the court and have the verdict. It is true we were not beaten in the court of last resort, but who of us wants to stand idly by and wait for uncertainties when a compromise can be made for a smaller sum than the decree of the lower court demands from us? The canal commissioners have on this occasion reduced their demands to such an extent that the trustees of this district can take the matter in hand and conscientiously vote for a final settlement of these perplexing and stubbornly contested questions.

The delay so far can, in my opinion, be made up to a great extent by requesting the contractors to work extra shifts, and it may be possible that the weather will be favorable to prosecute the work on the two delayed sections during the winter months. The committee on engineering should take this matter in hand as soon as the agreements between the canal commissioners and the sanitary district are executed and arranged with the contractors to make up for time lost.

Since the above statement of the litigation with the Commissioners of the Illinois & Michigan Canal was made, a compromise has been agreed upon between them and the trustees of the sanitary district. The details of this agreement are not yet made public, but it is stated that by it the drainage canal work can be resumed at once.

TWO NEW EAST RIVER BRIDGES connecting New York and Brooklyn are urged by Mayor Van Wyck, of Greater New York, and at his request the Municipal Assembly has appropriated the sum of $100,000 with which to pay the expenses of preliminary surveys, plans, estimates, etc. The Commissioner of Bridges has already begun work to secure this information. The location advocated for the first of these bridges, as was noted in Engineering News of Dec. 1, is at Blackwell's Island, the eastern terminus being in Long Island City. The second bridge, Mayor Van Wyck thinks, should be located somewhere between the present Brooklyn Bridge and the New East River bridge under construction, two miles north. The plans will be drawn for a bridge to accommodate general surface and elevated railway cars and street traffic.

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The report of Chief Engineer C. C. Martin, M. A. M., Soc. C. E., respecting the ability of the Brooklyn Bridge to carry safely its present loads, is a plain statement of facts which was much needed to disprove the silly stories of danger and disaster which have been recently published by some of the New York "yellow" journals. Among those best informed, it is almost needless to say, there has never been any doubt of the ability of the bridge to carry its additional load of elevated railway and surface electric cars with absolute safety. It has been equally recognized, however, that if this load was not uniformly distributed, that is if the cars were to be frequently bunched together over one portion of the suspended structure while other portions were clear the strains in certain parts of the structure might assume an undesirable and perhaps an unsafe character. Both of these facts have received ample recognition in Chief Engineer Martin's report. The accident of July 29 was directly due to the disobedience of the rules established by the expert engineers to regulate the trolley car traffic, and, as we stated at the time, the damage done, while immaterial in itself and certainly of no permanent injury to the supporting power of the bridge as a whole, was sufficient warning that the proper precautions in loading the bridge should not be lightly neglected. With the present careful regulation of traffic, a repetition of the accident, as Mr. Martin points out in his report, is little to be feared. That there is any danger of the cables breaking or the anchorage pulling up, as has been so alarmingly asserted by sensational daily papers, cannot be seriously assumed for a moment, with far greater loads even than those to which the bridge is now subjected. But even if the bridge were now loaded far nearer its limit of strength than it is, it would be very unwise to take the backward step of ordering the surface street cars and elevated trains from it and return to the old shuttle train system as has been proposed by some. It would be far better to expend money in strengthening the bridge to withstand the extra load. Some interesting statements respecting such a partial renewal of the bridge have recently been made by Mr. Wm. H. Hildenbrand, M. Am. Soc. C. E., in a letter to the "Railroad Gazette." Basing his estimates upon the cost of strengthening the Covington & Cincinnati suspension bridge, of which work he is the engineer, Mr. Hildenbrand calculates that the strength of the Brooklyn Bridge can be doubled at an expense of about $2,500,000. This work could be done without restricting traffic and would practically amount to the construction of another bridge in the additional facilities furnished for East River transit.

The appropriation of $100,000 with which to pay the expenses of preliminary surveys for two new bridges between New York and Brooklyn is briefly noted elsewhere in this issue. In his message requesting this appropriation, Mayor Van Wyck, it will be noticed, instructs the Commissioner of Bridges to locate one of the new structures somewhere over Blackwell's Island, and the other between the present Brooklyn Bridge and the New East River Bridge, which is being constructed about two miles further north. The character of bridge which is approved for both places, also, is a structure for general purposes and not an "all railway" bridge. Admitting that these two new bridges across the East River are needed, engineers may, we think, justly question whether the location and character of bridges advocated is entirely wise. In the nature of things the Blackwell's Island Bridge cannot have any large amount of local traffic for many years. A brief study of the map makes the reason for this clear. The population of the territory north of Newtown Creek, where the bridge centers, is small, while the more thickly settled district south of Newtown Creek has a much more direct route to Manhattan Island by the new East River Bridge. A field of usefulness in which a bridge at Blackwell's Island promises much, however, is in providing steam railway connection between Manhattan and the suburban towns of Long Island. A vast growth of population and traffic in this direction is possible as soon as direct railway connection can be had across the East River, and by combining with the Long Island R. R. to build a steam railway bridge over Blackwell's Island the city will bring about a really beneficial public improvement. It is not clear at present, however, that the local traffic for many years to come would justify the expenditure of from four to seven millions of dollars in a bridge designed only for general street traffic and street railways.

Further downstream, on the contrary, a bridge designed for general traffic is essentially demanded. It is very doubtful, however, whether the location which Mayor Van Wyck advises is the wisest one. For all the territory north of the New East River Bridge that structure is the natural route to New York, and for all the territory south of the present Brooklyn Bridge that structure gives the most direct connections. As a matter of fact a new bridge located between these two would afford a quicker and more direct route than they to only a very small territory. It needs only a very brief study of the map to convince one of this beyond any reasonable doubt. A part of Brooklyn, however, whose growth in business and population justifies the attention of the city authorities in their work of supplying a better East River transit, is South Brooklyn. Were the natural difficulties to bridge construction no greater here than they are further upstream there could be no question as to the superior advantages of this southern location for one of the proposed bridges. It is to be hoped, therefore, that while Mayor Van Wyck and Bridge Commissioner Shea have the question of additional East River bridges in hand they will give the matter of a bridge to South Brooklyn due study.

Elsewhere in this issue is given a description of the electric rack railway now being constructed to the top of the Jungfrau, in Switzerland. This road is exciting considerable interest among engineers owing to the fact that the dangers and difficulties of surmounting an Alpine peak nearly 14,000 ft. high are to be avoided by tunneling the entire distance from the point near the foot where the maintenance of a railway in the open becomes difficult and dangerous to a point directly underneath the highest point of the mountain, which will be reached by elevators in a 250-ft. vertical shaft. The plan contemplates about 6½ miles of single track tunnel through the solid rock, a track constructed in the most substantial manner, two electric power stations, suitable for high voltage transmission lines, and transforming stations where the current will be stepped down to lower pressure and delivered to conductors along the track, the whole involving an expenditure of nearly $2,000,000. This estimate for the cost of construction certainly appears small, but it is probable that those backing the scheme have satisfied themselves on this point.

The estimated number of passengers per year is placed at 10,000, which would seem a very conservative figure, considering that in the season of 1895 fully 160,000 persons visited Interlaken, only a few miles distant from Little Scheidegg, the starting point of this road.

It is of interest to note that the actual altitude reached by the Jungfrau railway is about the same as that reached by the Pike's Peak railway in Colorado. The reason for the great difficulty and danger in climbing Alpine peaks as compared with those of similar altitude in the Rockies, is to be found in the moister and cooler climate of the Alps, which keeps all their upper portions clad in perpetual snow and ice, and produces glaciers and avalanches.

The Division of Hydrography of the U. S. Geological Survey is engaged in the exceedingly useful work of bringing together for publication all available data concerning the water resources of the United States. This Division was organized in 1888, and the reports made are printed as separate volumes of the annual reports of the Geological Survey, and they already make an exceedingly valuable contribution to knowledge on this most important subject. In order to round out the general information now in hand it is desirable that the Division be placed in communication with all parties interested in this subject, and this list would include civil, hydraulic and sanitary engineers, instructors in these subjects, members of boards of health, and biologists and chemists interested in water supply. From the notes made by these men in the course of professional work it is hoped that the Division of Hydrography may be furnished, by correspondence, with any data relating to the following heads: Quantity of stream flow, if even the result of a single observation upon any stream in the United States; quality of water; natural lakes and ponds, with any information as to origin, size, depth, fluctuation in volumes or changes of temperature; irrigation canals and ditches; water power; storing and pumping water; pollution of stream, with the increase of population and development of industries; and of deep or artesian wells. Engineers and all interested in the development of the water resources of this country can further a work of the utmost importance to themselves and to the country at large, by either forwarding any such data that they may possess to Mr. F. H. Newell, Hydrographer, U. S. Geological Survey, Washington, D. C., or by sending in to Mr. Newell the names and addresses of those likely to possess such information. The work of this Division is one of the most generally useful and commendable falling within the province of the Geological Survey; and it is to be earnestly hoped that all available data on water supply will be placed at its disposal. Much information on this head is now hidden away in private note-books which if collated with similar data and made public would be of great value to the profession.

The letters published in our issues of Dec. 1 and Dec. 8 respecting the financial status and methods of operation of the Quebec Bridge Co. and the Montreal Bridge Co, have brought us several letters from Canadian engineers, warning bridge building firms and engineers in the United States to investigate very carefully the financial status of the Quebec Bridge Co. before expending money upon plans and estimates in response to its call for proposals. We judge, however, that what has already been printed in these columns will be sufficient to ensure this being done without our tak-

FIG. 6. POWER HOUSE FOUNDATIONS EXCAVATION.

FIG. 9. WHEELED SCRAPER AND GRADER WORK ON TOP SOIL EXCAVATION.

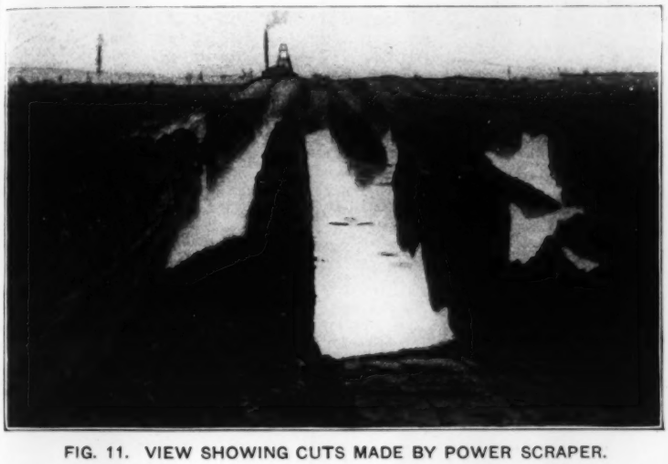


FIG. 11. VIEW SHOWING CUTS MADE BY POWER SCRAPER.

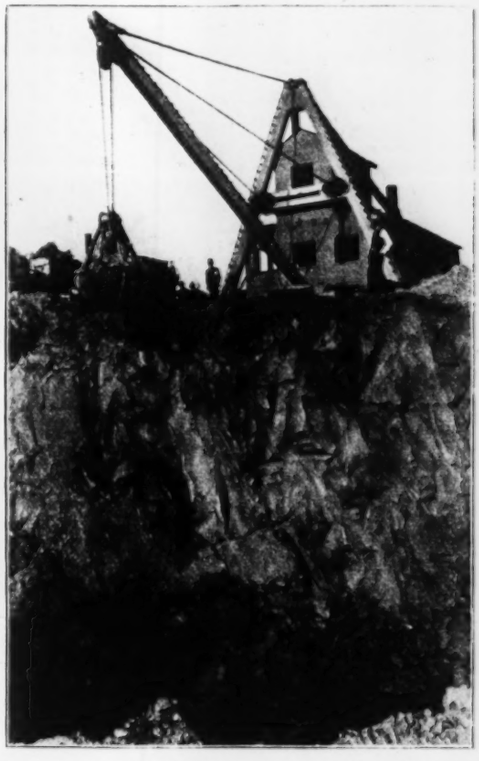


FIG. 5. "ORANGE-PEEL" EXCAVATOR WORKING IN CLAY AT POWER HOUSE FOUNDATIONS.

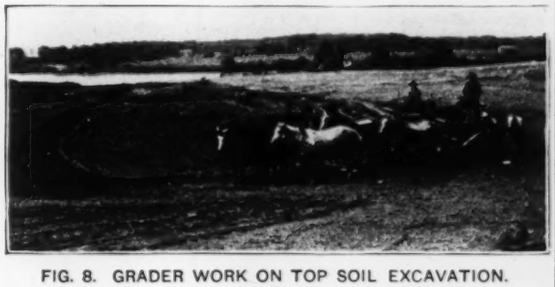


FIG. 8. GRADER WORK ON TOP SOIL EXCAVATION.

FIG. 12. A SCRAPER LOAD; POWER SCRAPER WORK.

FIG. 13. STEAM SHOVEL WORK IN ALDENS RIDGE CUTTING.

METHODS OF WORK ON THE ST. LAWRENCE POWER CO.'S CANAL.

St. Lawrence Construction Co., New York, N. Y., General Contractors.
The T. A. Gillespie Co., New York, N. Y., Contractors for Work.

ing space to print these letters and the rejoinder which, under our rules, we should be obliged to give the company criticised an opportunity to make. If the company can prove that its financial status and prospects are such as to warrant bridge builders in preparing plans for its work, those from whom it is soliciting such plans will doubtless not hesitate to demand the proof and to give it careful scrutiny.

PLAIN WORDS ABOUT THE MORGAN BILL FOR PURCHASING THE NICARAGUA CANAL CONCESSION.

There can be no doubt, in the mind of any one who keeps in touch with public opinion, that the events of the past year have made the American people practically a unit in favor of the construction of the Nicaragua Canal. Public sentiment at the present time would probably heartily approve the undertaking of the canal as a Government work. The idea has taken strong hold of the popular mind that the canal is essential to our national defence; and a large section of the country, including especially the Pacific coast and the states bordering on the Gulf of Mexico, is well persuaded that the construction is needed as a means of securing its commercial prosperity.

But the problem, as it is now before Congress, is not the simple one of deciding whether the nation shall take the funds from its treasury and build the canal as a national enterprise. The scheme as it is now presented to the Senate is for the United States to revivify the old Maritime Canal Co. of Nicaragua, and to build the canal under that name, incidentally paying to the holders of the stocks, bonds and other obligations of that bankrupt concern, some five million dollars, more or less. Now while public sentiment, as we have said, strongly favors the costruction of the canal, it is inclined to scrutinize very closely such roundabout methods of procedure as are proposed in the Morgan bill, now before Congress. Past experience has taught the public that partnership arrangements between a state or a city or the national government and a private corporation are to be looked upon with much suspicion.

To explain fully the present situation we shall have to review briefly the recent history of the Nicaragua enterprise. When the Maritime Canal Co. obtained its concessions from Nicaragua in 1888-9, it expected to raise capital in the financial markets of the world sufficient to complete the canal as a private enterprise. In fact, the concession from Nicaragua distinctly forbid the transfer of the concession or of the control of the company to any nation or government. Any such transfer was to work the forfeiture of the concession.

After securing its franchise and making its surveys, the canal company's promoters set about the task of securing funds; but in this it was unsuccessful. The investing public of the world refused to be convinced that the success of Suez could be repeated in Nicaragua, and while the company did raise the considerable amounts that were necessary to pay for its surveys and such preparatory work as it undertook, it did this by disposing of its securities at a great sacrifice. It became evident that the canal was too risky a scheme to attract private capital; if built at all, it must be as a Government work; and the managers of the canal company, as the only hope of securing a return for the money they had put in, began their endeavors to dispose of their concession to the Government. At nearly or quite every session of Congress for the past seven years, bills for this purpose have been before Congress; and their advocates have pushed them in a manner which gave good ground for their belief that they were more concerned in the rescue of the canal company's stock and bondholders from loss than they were in the protection of the Government's interests, and securing the construction of the canal.

The general scheme in the various bills before Congress has invariably been to have the Government guarantee the bonds of the canal company to the amount of about $100,000,000, and receive in return $70,000,000 of the company's stock. As it became more and more evident that Uncle Sam could not be induced to pull chestnuts out of the fire to any such extent, the Maritime Canal Co. have reduced their demands. In the bill as presented by Senator Morgan last June, according to the best information at hand, it was proposed to give the canal company stock and bondholders and creditors $4,500,000 in bonds and about $7,000,000 stock in exchange for their present holdings. In the bill as reported by Senator Morgan on Dec. 7, this has been changed, and it is now proposed to give the company the sum of $5,000,000 in bonds for all it has and owns, and to wipe out all obligations of every kind. The old company is, in fact, to disappear, and the new company under the same name is to be practically a department of the United States Government, all its directors being appointed by the President.

There are two questions which ought to be definitely settled before Congress passes the bill for which Senator Morgan has so zealously labored. The first is what the United States is to receive for the $5,000,000 which it is asked to pay, and second, whether it is desirable that the Government shall masquerade as a private corporation in carrying out the work of building this canal.

The actual visible assets of the Maritime Canal Co., and its Construction Company offshoot, are admitted to be trifling in amount. There is about 11 miles of railway embankment running west from Greytown, across the swamp section, on which, according to all accounts, the ties have disappeared and the rails are fast approaching the traditional two streaks of rust. The Greytown harbor works have been wiped out by the seaworms and the silt carried by the tidal currents. There are a few buildings at Greytown and a small amount of machinery, dredges, etc., all of which has experienced the deterioration due to half a dozen years of tropical exposure. Finally, there is, or was, a couple of miles or so of ditch dredged through the swamp. It seems to us that the fair basis for estimating the value of this plant is to see what it would be fairly worth, or what amount of expenditure its use would save if the Government should now undertake to utilize it in the construction of the canal. From all the information available, it seems probable that the sum of $200,000 would be ample to cover the value of the existing plant and works on the basis above outlined.

The second asset which the Maritime Co. has to dispose of is its surveys, and the maps, plans, designs, etc., which were made by its corps of engineers. Just what value may be fairly placed on this asset, it is difficult to say; but there are good reasons for declaring that the estimate should not be a high one. Much of the work done by the company's engineers was in working up the details of its high-level navigation scheme from the Ochoa dam to the great divide cut. The defects and dangers of this plan are now well known, and it is probable that the canal, if built, will pursue a different route from the great divide cut to the San Juan. Similarly on the western division, it is not at all certain that the canal company's location will be the one adopted. Under these circumstances, the canal company, it seems to us, can hardly claim payment for its work in fixing a location which is afterward discarded.

On the other hand, it is certainly true that a considerable amount of the topography taken and borings made by the company will be of use to the United States; and if this is so a fair valuation should be placed on this work. We cannot pretend, of course, to name anything more than approximate limits to the estimate of such work, but it seems to us that the sum of $300,000 should be ample to cover it, or a total of $500,000 for the entire works, surveys and records belonging to the company.

The remaining asset of the company is its franchise from the states of Nicaragua and Costa Rica, and it is this which Senator Morgan and the canal promoters have chiefly urged as worth the price which they have asked the Government to pay. Recent events, however, have not been calculated to improve the position of those who value this franchise so highly. As our readers already know, Nicaragua has taken formal action declaring that the franchise will be forfeited next October, and has granted a new franchise to a new set of financiers which will go into effect when the Maritime Canal Company's franchise expires.

The ground on which the franchise is declared forfeited is the following clause in the Maritime company's charter:

> Article 43. A term of ten years is also granted to the association for the construction, completion and opening of traffic and the canal for maritime navigation. However, should events of main force arise, duly justified and sufficient to impede the regular progress of the works during the period of the said ten years, an extension shall be granted equal in duration to the time that may have been lost by such delays. If at the expiration of the ten years aforesaid the works should not be completed so as to have the maritime connection between the two oceans opened, in consideration of the great capital the company may have invested in the enterprise and the good will and ability it may have shown and the difficulties encountered, the republic binds itself to grant a new extension."

The phrase "events of main force" is indefinite, it is true, but the idea apparently is to give the company the benefit of an extension to compensate for delays due to strikes, wars, pestilence, earthquakes or other great public calamities. It can hardly be seriously contended that the clause had reference to mere inability to finance the enterprise.

The second clause of the article evidently refers to the situation which would have existed had the company proceeded with actual construction and been unable to complete the canal within the specified time. Had it done this, it might without doubt claim of Nicaragua an extension of the franchise period. As the case actually stands, however, the company can hardly claim to have invested "great capital" in the enterprise; the "ability" has certainly not been manifested in the actual work of construction, and "the difficulties encountered" are not such that an extension of the contract period would be of any benefit to the company, unless it can turn over its franchise to the Government, which the terms of the franchise distinctly forbid.

This, then, is the situation. The United States is asked to pay $5,000,000, more or less, for a franchise, which will in the first place be invalidated on its face by transfer to the Government, and which, in the second place, has been declared by the state that granted it to be forfeited by its own limitation at a date only nine months distant. The present holders of the franchise claim, indeed, that for various technical reasons, which we cannot take space to enumerate, they have a right to an extension of the time allowed for construction; but they have not obtained such an extension.

Suppose Congress passes the Morgan bill, and the United States purchases this concession. Shall this great and powerful nation then compel Nicaragua by force or by the threat of force to reverse its formal action terminating the Maritime Canal Company's concession? Of course we can do this, if we choose; but it would be an act for which every self-respecting American would blush with shame. Nicaragua is an independent state, insignificant, it is true, but nevertheless entitled to the same just treatment at our hands as any other friendly power. It is not long ago that we rapped England over the knuckles to remind her that might did not make right. We then established the principle that a stronger power may not dictate to a weaker, when the latter offers to submit its case to arbitration by disinterested parties. Shall we use compulsion in Nicaragua, when we compelled England to refrain from compulsion in Venezuela?

We believe that there can be but one answer to this question in the mind of any intelligent American. If we purchase the franchise which Nicaragua has declared forfeited, we owe it to ourselves to treat her claims with the same respect that we would if they were made by France, or Germany or Russia. If Nicaragua appeals to arbitration to decide whether her annulment of the Maritime Canal Company's franchise was warranted, to arbitration it must go. In other words, this Government must take up the dispute of the Maritime Canal Co., before some international tribunal, and must go into all the petty details of the various negotiations between Nicaragua and the canal company extending over a period of a dozen years. The result of such an arbitration must at best be doubtful, for, as we have seen above, Nicaragua had, it is extremely probable, a legal right to terminate the Maritime company's charter. The time such an arbitration would occupy can be estimated by recalling the fact that the arbitration between Great Britain and Venezuela has not yet reached an end. Surely, then, the passage of

the Morgan bill is not the way to hasten actual construction of the canal. On the contrary, the purchase of the Maritime Canal Company's charter can only land us in a maze of complications, of which no man can discern the outcome. The excuse which has been given for pushing the Morgan bill before Congress in advance even of the report of the engineering commission, is that haste is demanded in the work of actual construction. The flimsy nature of this excuse is now apparent

Let us next consider the question whether if the United States is to construct the canal, it should do so under the guise of a private corporation. The stock reason for this course has always been that it was a way of getting around the Clayton-Bulwer treaty, under which we agreed to join hands with England in the construction and control of the canal. No more peurile argument was ever conceived. If the United States can own the franchise, furnish the money and hold practically all the securities of a company organized to build the canal, it can equally well undertake it as a piece of public work as it would any river and harbor improvement, so far as its obligations under the Clayton-Bulwer treaty are concerned. It has been claimed for American diplomacy that it is straightforward and frank; and that we scorned subterfuges and technical evasions, holding to the spirit rather than the letter of our obligations. What becomes of this claim if we try to get around a treaty with England, our best friend among the great powers of the world, by such a transparent evasion?

There are other reasons why the United States should not pose as a fictitious corporation to build this canal. The checks and safeguards which long experience has developed to protect the Government from fraud in the execution of its works would all be eliminated if it were to do this work under the guise of a private corporation. The eleven directors appointed by the President would have free and unchecked control over expenditures amounting to over a hundred million dollars. What a chance for corruption and plunder! Is it some foresight of this and of the harvest that will await those who may expect to have the spending of this enormous sum that causes the unseemly haste to rush the Morgan bill through Congress at the beginning of the present session?

Let us turn now to another aspect of this question. Those who are endeavoring to push the Morgan bill through Congress are privately urging upon the Senators and Representatives that it is really as a measure of justice to those who have invested their money in the canal enterprise that the Morgan bill is desired. They acknowledge that the existing plant and the records and surveys of the company are only worth a small sum, and that the company's franchise is practically void; but they urge that those who put their money into the canal enterprise should not be compelled to suffer total loss. They claim that motives of patriotism, as well as the hope of profit, influenced many of those who invested their money in the company's stock and bonds, and that it will be unjust and unfair for the United States to now take up and complete the enterprise and leave in the lurch those who carried it through its initial stages.

We are far from denying that there is some reason in this presentation of the case. It is quite possible that the nation ought to pay to those who in good faith spent money upon this enterprise, something more than the present value of the plant and surveys. But what we would urge is that if this is to be done, let it be done openly and squarely. Let it be plainly understood that the Morgan bill is a bill to repay to Maritime Canal stock and bondholders their expenditures upon the enterprise. If this is not done, and the bill is passed in its present form, the certain result will be a scandal and an investigation, which will very probably put the action of many members of Congress in a worse light than they deserve It may be just and equitable to pay $5,000,000 to Nicaragua stock and bondholders; but the people will not be convinced that there has not been wholesale fraud if this payment is made in the guise of purchase money for something worth only a tenth part of that sum.

Still another serious question to which Congress should give heed is the question what is to become of the $5,000,000 which it is proposed by the Morgan bill to turn over in a lump to the Maritime Canal Co.? How much would the genuine investors in the company receive, and how much would be diverted on one pretext or another into the pockets of those who have already made profits by their manipulations of the company's stock? How much of the five millions would be allotted to those who paid for their stock only in "influence?" Are some of the newspaper proprietors whose journals have been most vociferous in urging the speedy passage of the Morgan bill to have a goodly share? Is the anxiety to further the interests of the Maritime Canal Co. which certain high public officials have displayed, explainable on any other grounds than pure unadulterated patriotism?

These are some of the questions which the public would like to have answered before Congress turns over five million dollars of the public money to the Maritime Canal Co. If the bona-fide investors and creditors of that company are deserving of relief at the hands of the Government it is surely not too much to ask that the company shall open all its books to public inspection, and that some pains at least shall be taken to see that the money goes to those who have a reasonable claim upon it, and is neither gobbled up by those who are on the "inside," or frittered away in litigation.

We have given in detail the reasons why the passage of the Morgan bill is not the road to speedy construction of a Nicaragua canal. Just what course Congress should take to this end, lack of space forbids us now to discuss. This much, however, is clear; that the acquisition of the Maritime Co.'s concession will give the United States nothing, either as respects the Clayton-Bulwer treaty, or its relations to Nicaragua, that it cannot better and more quickly attain by direct diplomatic negotiation through its own accredited agents. The quicker Congress makes clear that it is not in the business of bargaining with concession-mongers, no matter what their political or financial backing, the more certainly will the public confidence in the Government's ability to handle the many grave problems now pressing upon its attention be confirmed.

END PANELS OF A VIERENDEEL GIRDER OF 103 FT. SPAN, AFTER SUBJECTION TO A BREAKING LOAD.

LETTERS TO THE EDITOR.

Portable Forges with Detachable Parts

Sir: In the Dec. 1 number of your valuable journal you illustrate and describe a forge put up by the Buffalo Forge Co. It is, at least, intimated in the article that the forge is new.

Please look over the enclosed illustrations of our forges. A comparison of the two forges may be interesting. You may never have seen our machines. Some of your advertisers use them. Our forges built the good ship "Oregon."

Yours truly,
David Cumming.

278 N. Hoyne Ave., Chicago, Ill., Dec. 9, 1898.

(The forges illustrated in the circulars enclosed with the above letter show many points of similarity to the one illustrated in our issue of Dec. 1st.—Ed.)

A Remarkable Belgian Bridge Design.

Sir: We send you herewith the latest, if not the most brilliant, development of Continental bridge engineering, entitled "The Bridge System of Vierendeel." This monograph was sent to us by a friend of ours now in Europe, whose desire to give us valuable information exceeds his engineering discrimination. We believe that the bridge engineers of this country will find it amusing, if not convincing, and that they will agree with the writer that the true inwardness of the design is an attempt to patent a hole in a web plate, and the bigger the hole the greater the invention.

It is difficult to imagine what diagonal web members have ever done to this inventor that he should leave them out in the cold. He seems to know of their existence, as witness the sway bracing, and if filletted holes are good enough for the main trusses, why should he not use them for sway bracing? It is needless to point out that the liberal width of his vertical members and the liberal size of his corner fillets enables the structure to show some resistance under load, but what shall we think of an engineering community which would give grave consideration such a monstrosity?

Yours truly,
H. S. Wood, C. E.,
Engineer San Francisco Bridge Co.

World Building, New York, Dec. 6, 1898.

(The pamphlet to which our correspondent refers was briefly noted some months ago in our column of "New Publications." It is quite as remarkable a curiosity as the above letter would indicate. The design will be apparent from the accompanying illustration, which shows the two end panels of a bridge of this type which was broken under a test load at Tervueren, at the time of the Berlin International Exposition of 1897. The bridge had a span of 103.3 ft., and a depth of 10 ft., and was designed for a railway bridge to carry a load of about 3,150 lbs. per l.n. ft. The inventor claims an economy in material "which increases with the span," and attempts to defend himself against the charge of costly construction. The "Notes for the Jury," as the work is entitled, enters into an elaborate description of the principle advocated, and into the calculation of values to be obtained. In the actual test, the weight was applied in the form of pig-iron; and though the claim was made that the structure would carry 600 metric tons distributed load before breaking, it actually failed, in the web system, as shown in the cut, under a load of 410 to 420 tons. The inventor explains this by saying

that it was "impossible to apply the load fast enough"; and the fact that it was loaded with 370 tons over night "accounts for the mischief." To an American engineer the manner of failure is decidedly interesting, as it shows that the structure failed exactly where theory would indicate probable failure. The inventor's bridge is made up of rectangular instead of triangular elements, and while its weakness is somewhat concealed by the riveted construction and the bracing at the corners of the rectangles, it is, of course, an engineering absurdity.—Ed.)

Estimated and Actual Cost of the Chicago Drainage Canal.

SIR: It is not my purpose to mix up with the entanglements of the Erie Canal, but I cannot let statements made, in ignorance of the facts, by Mr. George W. Aldridge, Supt. of Public Works, under date of Oct. 30, and quoted in your issue of Nov. 3, 1898, go uncorrected so far as they relate to the Sanitary District of Chicago and its work. You quote him as saying that he "challenges the commission or the public in general to point to any work of similar magnitude where greater diligence has been shown or where the estimates have come as near to accomplishing the work required to be done as has been accomplished in this instance." Then follows an alleged table of "comparison" between the original estimates and the actual cost of various notable public works:

	Estimated.	Actual.
Erie Canal	$4,926,738	$7,143,789
Enlargement	23,402,863	32,008,851
Oswego Canal	227,000	565,437
Enlargement	1,926,339	2,511,992
Champlain Canal	871,000	1,746,062
Black River Canal	1,068,437	3,157,208
Hoosac Tunnel	1,948,557	20,241,842
Manchester Ship Canal	26,000,000	87,351,105
Chicago Drainage Canal	12,000,000	*37,671,652
Hudson River Improvement	2,000,000	2,600,000
State Capitol, Albany	4,000,000	24,000,000

*This includes $27,303,216, and an estimate of $10,538,436, to complete the work.

In his table of comparison of estimated and actual cost, he gives for the Chicago Drainage Canal, estimated, $12,000,000; actual, $37,671,652. Where does he get these figures? For **five** years and six months I have been Chief Engineer of this work, and no such figures have ever come under my observation. Turning to the Records of the Board of Trustees, we find, on page 118, under date of Jan. 10, 1891, a report from W. E. Worthen, Chief Engineer, and John Newton, Consulting Engineer, from which I **quote:**

We estimate the total cost of entire line of eighteen (18) feet water depth by way of Ogden Ditch at $25,700,000.

On pages 148-50 of the proceedings for March 7, 1891, will be found an address to the citizens of the Sanitary District of Chicago, signed by Richard Prendergast (then President), Arnold P. Gilmore, Christoph Holtz, Henry J. Willing, Trustees. In this address the estimate of Jan. 10, above quoted, is given with the addenda, "In this carefully prepared estimate the following items are not provided for: Right of way, dumping ground and transportation of waste material to place of deposit; further charges for straightening the South Branch of the Chicago River; changing bridges, etc., to produce a larger flow, to be done by the city."

The canal is now so nearly completedthat the margin of possible error in approximating the cost of the unfinished work is very small, and we have a channel whose minimum depth of flow is not "fourteen feet," nor "eighteen feet," but twenty-two feet, and the work embraces not alone the main channel contemplated in the reports above referred to, extending from Robey St. to Lockport, but also covers the diversion of the Desplaines River; the deepening, widening and bridging of the Chicago River, and the deepening widening and bridging of the Desplaines River from Lockport to the mouth of Hickory Creek south of the city limits of Joliet. Nor is this all. The character of the work has been changed in many particulars from that contemplated in the original estimates, notably in the item of masonry; massive walls laid in cement mortar have been substituted for dry rubble. The bridges are being built in conformity to the heaviest modern specifications, and no proper expenditure necessary to make the work first class in every particular has been omitted. The resulting cost to the Sanitary District is shown in the following statement:

Cost of Main Channel and Auxiliary Work, Sanitary District of Chicago, Under Contract and Estimated to Date of Proposed Completion, July 1, 1900.

Construction.		
Diversion of Desplaines River..	$1,000,156.38	
Main channel, Roby St. to Lockport	18,416,024.46	
Controlling works	245,536.65	
Railroad and highway bridges..	1,318,236.71	
		$20,979,954.20
Chicago River improvement....	$678,614.39	678,614.39
Desplaines River improvement from Contrig Wks. to Joliet..	690,823.77	690,823.77
		$22,349,392.36
Right of way and lands		3,141,807.62
Total for construction and lands		$25,491,199.98

Administration Account.	
Engineering, legal, clerical and police	2,080,789.62
Maintenance account	92,426.19
General account	480,115.21
	$28,144,531.00
Amount to be paid as capitalization for maintaining railroad bridges, etc.	267,389.00
	$28,411,920.00

The interest charges up to July 1, 1900, will amount to $3,469,804.85. Bonds to be retired, $830,000. To cover contingencies, an allowance of 10%, or $250,000 for unfinished work would be proper.

This exhibit is an ample vindication of the methods which have been obtained on this work and the results stand as a monument to the character and ability of the men to whom Chicago has intrusted the expenditure of its millions.

Yours truly,
Isham Randolph, Chief Engineer.

Chicago, Ill., Dec. 6, 1898.

THE ELEVATOR ACCIDENT IN THE MANICE BUILDING, NEW YORK CITY.

On the afternoon of Dec. 6 an accident occurred to the passenger elevator in the Manice Building, an 11-story office building, at the corner of Pine and William Sts., New York city, which caused the death of one man and the serious injury of two others, all of them passengers in the car at the time.

The accident was of an unusual character, consisting in the fall of several of the cast-iron weights forming one of the counterweights from the top of the shaft. According to the best information available, the accident appears to have occurred about as follows:

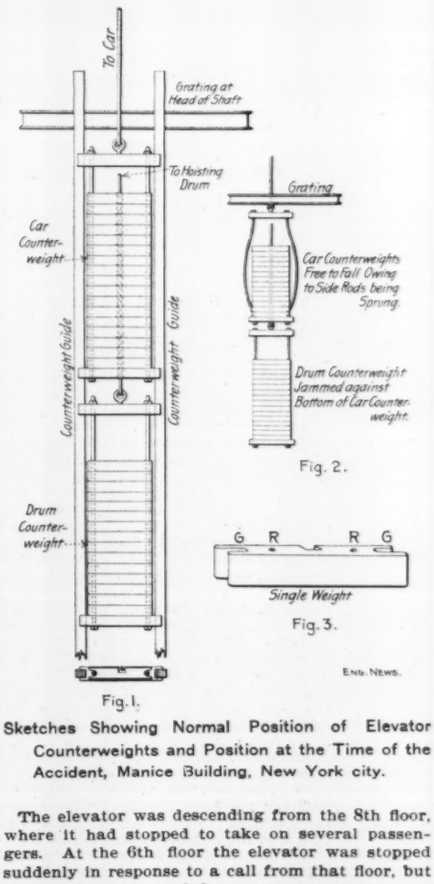


Fig. 1. Fig. 2. Fig. 3.

Sketches Showing Normal Position of Elevator Counterweights and Position at the Time of the Accident, Manice Building, New York city.

The elevator was descending from the 8th floor, where it had stopped to take on several passengers. At the 6th floor the elevator was stopped suddenly in response to a call from that floor, but as the car was crowded no more passengers were taken on and the down trip was continued, the motion being noticeably jerky and irregular. The final stop was made below the ground floor, the car striking the buffers with considerable force, and an instant later several of the cast-iron counterweights crashed through the frail car roof, after a fall of 11 stories, with the fatal results already mentioned.

The equipment was the standard Otis electric elevator, model of 1895, provided with limit stops, car safeties and the usual car control. Running up one side of the shaft were two counterweight guides for the two counterweights used. These were suspended, as shown in the sketch, Fig. 1, the upper one being the car counterweight, which is hoisted by the downward pull of the car, and the lower one the drum counterweight, which is hoisted by a cable wound on the hoisting drum in the opposite direction to the car lifting cable. Just under the sheaves at the head of the elevator shaft was the usual grating required by the city Building Department to guard against any part of the overhead machinery falling upon the elevator car.

The cause of the accident seems to be that the car on the down trip descended far enough below the lower floor level to jam the car counterweight against the overhead grating, and the closely-following drum counterweight striking the bottom of the upper weight lifted it and spread the suspending rods, as shown in the sketch, Fig. 2, sufficiently to free several of the weights, which toppled over and fell down the shaft. Referring to the accident and its cause, Mr. F. Frankenberg, City Elevator Inspector, is quoted as saying:

The cause of the accident was that while the car was on the down trip the operator failed to judge the ground floor properly. The car struck the bumpers at the bottom of the shaft, causing the back drum weights to raise the car weights, thus tipping the car weights into the shaft. Had the automatic stop on the motor been set properly for the down stop, and the car properly stopped at the ground floor, the accident would not have happened.

In making repairs the old cast-iron car counterweights were replaced by lead weights, thus shortening up the counterweight and giving more clearance between the overhead work and the traveling weights. The single weights shown in Fig. 3 are the same in form as those so generally used for elevator counterbalances, but to avoid any possible future accident both counterweights will be provided with bolts running through holes drilled in the weights, at the points R, R, Fig. 3.

The accident will doubtless serve to call attention to the need of greater care in the designing of counterbalance weights and their attachments. The common method of assembling counterweights with nothing but gravity to hold the bunch of weights in position is objectionable; and it seems clear that the several weights should be firmly bolted together. Of course it goes without saying that the construction of the automatic limit stops should be such that by no possibility of careless handling can the car or counterweight bring up with a shock at either the top or bottom of the shaft. If the designer is unable to effect this with absolute certainty, then elastic buffers should be provided to receive the counterweights at either end of their travel and prevent their bringing up with such a shock as to cause undue strain in the ropes or other parts of the machinery.

SHIP-CANAL STATISTICS or the growth of commerce on the great canals of the world are treated by the U. S. Bureau of Statistics, as follows: The Suez Canal in 1869, when first opened, showed a net tonnage of 6,576 tons; in 1870 this was 436,609 tons; in 1891 the figures reached 8,698,777 tons, since which time there has been comparatively little change, the figures for 1897 being slightly below those for 1896. The Kaiser Wilhelm canal, in operation but three years, shows an increase of 59% in that period; or, 1,505,983 tons for the first year, and 2,469,795 tons for the fiscal year ending March 1, 1898. The St. Mary's Falls canal, connecting Lake Superior with the lower lakes, shows a more rapid rate of gain than Suez. In 1881 the freight tonnage through this canal was 1,567,741 tons; in 1885 it was more than three million tons; in 1887, over five million tons; in 1890 over nine million; in 1894 over 13 million, and in 1897 over 18 million tons. The freight tonnage passing through the Detroit River has also increased from 9,000,000 tons in 1873 to 23,000,000 tons in 1896. The Welland Canal shows a slight gain of from 819,934 tons in 1880 to 1,279,987 tons in 1896. On the other hand the New York State canals show a steady decrease in tonnage since 1880. In 1880 the freight carried to tidewater amounted to 4,067,402 tons; in 1890 this was 3,024,765 tons, and in 1897, 1,878,218 tons. In 1877 the average rates per bushel for wheat, from Chicago to New York, by lake and canals, was 11.24 cts.; in 1887 it was 8.5 cts.; in 1897, 4.25 cts. In the combination of lake and rail freights, the rates fell from 15.8 cts. per bushel, in 1877, to 12 cts. in 1887, and 7.37 cts. in 1897. All-rail freights fell from 20.3 cts. per bushel in 1877, to 15.74 cts. in 1887, and 12.32 cts. in 1897.

METHODS OF TESTING INDICATORS.*

By D. S. Jacobus, M. Am. Soc. M. E.†

Indicators should be tested both before and after they are used on an engine, or other trial. One object of testing the indicators before the trial is to make certain that there is no excess of friction, which, if present, will form double lines on the test diagrams. If double lines are found it is generally due to some irregular action of the spring, in either throwing the piston of the indicator out of line, or in forcing it against the side of the cylinder.

A mercury column will often give incorrect results when used in testing an indicator with steam pressure unless it is allowed to stand a long time at each pressure before taking a reading, on account of the fact that a considerable pressure is required to overcome the inertia of the mercury in the column if the latter is in motion, and there may be pulsations which will affect the result.

The apparatus used for testing indicators at ordinary pressures above the atmosphere is shown in Fig. 1. The indicator is placed at A on top of the cylinder B. The cylinder B is made of a piece of 6-in. standard pipe about 2 ft. long. The pressure is measured by means of a plug and weight device C, which is spun around so as to eliminate the effect of friction. The bottom of the plug is at the same level as the pipe D. The U-shaped pipe E is filled with oil. Before starting to calibrate the indicator the pet-cock F is opened slightly, in order to allow any air in the pipe G and the siphon H to escape. The siphon H is surrounded by water contained in the vessel I, which condenses the steam which enters it through the pipe D, so that when all the air present is allowed to escape through the pet-cock F, the pipe G and the siphon H will be filled with water. J is a pet-cock for removing any water that may collect at the bottom of the siphon E, after the apparatus has been in use for a long time. The pressure is adjusted by regulating the amount of opening of the valve K in the supply pipe L, which furnishes steam, water, or compressed air to the apparatus, and also by adjusting the valve M in the escape pipe N. O is a valve for removing any water which may collect in the bottom of the cylinder B when steam is used, and for draining out the water after calibrating an indicator under hydrostatic pressure. The plan of the plug and weight device C is limited in its movement by means of a fork, which comes in contact with it only when the pan is in the extreme positions; the two prongs of this fork are shown in section at P and Q. R is a gage for showing the approximate pressure. The readings of the gage R are not used in testing the indicator, but as general guide in the use of the apparatus. The diameter of the plug in the plug and weight device C is 0.5-in., and the hole in the bushing, 0.5005-in. Both the plug and bushing are ground true. The average area of the plug and of the hole in the bushing is used in calculating the weight required for a given pressure.

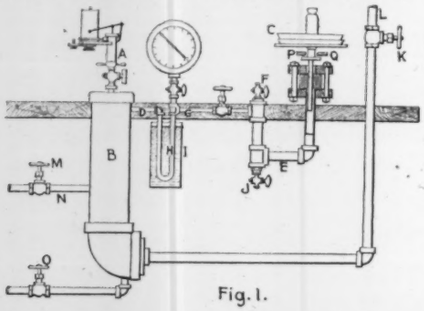


Fig. 1.

Fig. 1.—Apparatus for Testing Between Atmospheric and Boiler Pressure.

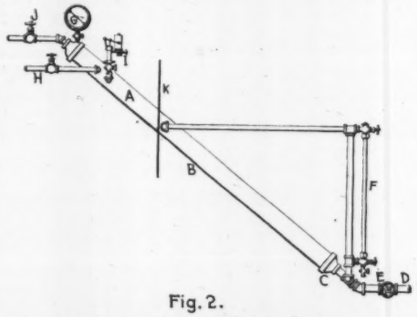


Fig. 2.

Fig. 2.—Apparatus for Testing at Pressures Above Boiler Pressure.

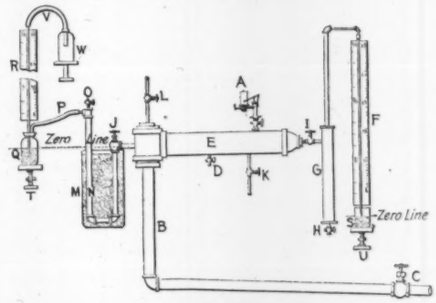


Fig. 3.

Fig. 3.—Apparatus for Use at Pressures Between 15 lbs. Above Atmosphere and Vacuum.

APPARATUS USED IN TESTING INDICATORS AT THE STEVENS INSTITUTE OF TECHNOLOGY, HOBOKEN, N. J.

In the apparatus, arranged as just described, one person adjusts the pressure and traces the lines on the indicator diagram. If so desired, one person may adjust the pressure, and a second trace the lines on the diagram. To arrange the apparatus for this purpose, the blow-off pipe from the valve M is led to a point near the valve K, and a second valve, for adjusting the rate of flow through the blow-off pipe, is placed near the valve K, where it can be operated conveniently by the party who adjusts the pressure. The apparatus which we use is arranged in this way.

In testing indicators with steam pressure, the steam is brought to the maximum pressure to which the indicator is to be subjected; the indicator cock is then opened and closed quickly a number of times, in order to heat the indicator. The steam is then released from the cylinder B, and the atmospheric line is taken after turning the indicator cock to the proper position. In taking the atmospheric line, as well as the lines for any other pressure, the pointer of the indicator is first pressed upward, and then released and a line taken, then pressed downward and released and the line taken, the indicator being rapped sharply with a small wooden stick before taking each line, as has already been explained. After obtaining the atmospheric line, steam is admitted through the valve K, until the pan and weight device is balanced while being rotated. This requires a very fine adjustment, and the line is not taken until there is no tendency for the plug and weight device to either rise or fall.

An apparatus for testing at pressures higher than can be carried on the boilers is represented in Fig. 2. It consists of a pipe A, 4 ins. in diameter and about 8 ft. long, placed in a slanting position, and arranged so that the lower end, from B to C, can be heated by means of Bunsen burners. The pipe D is connected to both a water and steam supply. Water is first admitted through the valve E, until it nearly fills the gage glass F, after which steam is admitted, and the water in the pipe A is heated, and the pressure, as indicated by the gage G, is brought to that of the entering steam. The valve E is then closed, and the pipe A is heated by means of the Bunsen burners until the desired pressure is obtained. The pipe H leads to a plug and weight device, similar to the one shown in Fig. 1. The indicator is placed at I. In the calibration the pressure is brought to slightly above the maximum, and is then adjusted by opening the valve J. The first line taken is for the highest pressure, and the pressure is diminished for taking the other lines of the diagram by adjusting the height of the flames of the Bunsen burners, and the amount of opening of the valve J. Two lines are taken for each pressure, in the same way as described for the aparatus shown in Fig. 1. K is a screen for confining the heat to the lower end of the pipe A. The upper end of the pipe A is encased with a non-conducting covering, to diminish the radiation. An asbestos shield is placed on top of the lower end of the pipe to partly confine the flames of the Bunsen burners and thus render them more effective.

The apparatus employed in testing springs used under a vacuum is shown in Fig. 3. The indicator is attached at A to the top of the horizontal cylinder E. The pipe B leads to a vacuum chamber and pump, and slopes downward, so that no water can collect in it. The amount of vacuum is regulated by adjusting the valve C, leading to the air pump, and by admitting a small amount of air through the pet-cock D. The vacuum gage at F is graduated in inches of mercury and in pounds per square inch. G is a chamber for condensing any steam which may pass through the valve I, and thus prevent it from condensing on top of the mercury in the gage F. The water which collects in G is drawn off through the pet-cock H. The height of the mercury cup S is adjusted by means of the screw U, so that the surface of the mercury is on the same level as the zero point of the scale. There is a straight edge in front of the mercury cup S, at the same level as the zero of the scale, which makes it easy to adjust the level of the mercury to the proper height.

The apparatus may also be used for testing springs at pressures up to 15 lbs. above the atmosphere, the mercury column R being used for this purpose. Where a spring is used for both a slight pressure and a vacuum, the entire calibration can, therfore, be made with the apparatus shown in Fig. 3.

In measuring a pressure above the atmosphere, the valve I is closed and the valve J opened. The pressure of the steam acts then on the water contained in the U-shaped pipe N, and is transmitted through the hose connection P to the water in the upper part of the closed bottle Q. The lower part of the bottle Q is filled with mercury, and when the pressure increases this mercury is forced upward in the column R. The height of the bottle Q is adjusted by means of the screw T, so that the mercury is brought opposite the zero line of the scale, a straight edge being used in the front of the bottle, at the same level as the zero line of the scale, as in the case of the vacuum gage F. In adjusting the bottle Q up and down, the glass tube forming the column moves up and down with the bottle; this tube bears directly against the scale on which the pressures are read. Should the pressure be accidentally raised to such an extent that the mercury will be blown out of the column, the mercury will pass through the rubber hose V into the bottle W.

In testing the indicator, it is first heated by means of steam, admitted through the valve K, until it attains what is considered to be about the average temperature to which it will be subjected in the test. Two lines are taken at each pressure, and all other details in making the tests are the same as have already been described.

*Condensed from a paper presented at the New York meeting of the American Society of Mechanical Engineers.

†Professor of Experimental Mechanics, Stevens Institute, Hoboken, N. J.

THE SAFETY OF THE BROOKLYN BRIDGE.

The dangerous overloading of the New York & Brooklyn Bridge, and even the possibility of its early destruction by the loads at present carried by it, have recently been so strongly asserted in the daily press that the emphatic statement of the perfect safety of the great structure by its Chief Engineer and Superintendent, Mr. C. C. Martin, M. Am. Soc. C. E., which we present here, will be of interest to engineers. Mr. Martin's report was called forth by the public clamor following the accident of July 29, 1898 (Eng. News, Aug. 18, 1898), when a blockade of vehicles and trolley cars on the south roadway, combined with the very great expansion of the cables by the excessive heat, caused a slight buckling of the lower chord members of three of the six stiffening trusses. The accident, while trivial in itself, and certainly of no injury to the supporting power of the bridge as a whole, naturally excited the attention of the bridge officials, and caused considerable alarm to many of the more timid passengers over the structure. It was for the purpose of allaying this alarm, and also to provide the revised statement of loads and strains made necessary by the admission of the surface street cars and elevated railway trains of the bridge, that Chief Engineer Martin's report, which we publish here, was made. The report, practically in full, was as follows:

The loads on the bridge at present are made up as follows:

Bridge cars—the trains are made up of four cars: a motor car, which when fully loaded weighs 44 tons; three passenger coaches, fully loaded, weighing 28 tons each, 84 tons. Total weight of train, 128 tons. This equals 256,000 lbs. The trains run at 11.3 miles per hour, and if they run on 45 secs. headway they will be 748 ft. apart from front to front. Hence, the above load will be distributed over 748 ft., giving a load per lineal foot, for both tracks, of 690 lbs.

The trolley cars loaded weigh each 14 tons, or 28,000 lbs., and are spaced 102 ft. apart; hence this load per lineal foot, is, for both roadways, 550 tons.

The load on the carriageways is taken to be two continuous lines of trucks (one on each roadway), each truck occupying 20 ft. and weighing 2.75 tons, 5½ tons on both roadways, or 11,000 lbs.; hence the load from this source is, per lineal foot, 550 tons; total 1,790.

The load on the promenade is taken at 50 lbs. per sq. ft. (although Mr. John A. Roebling says in his original report of 1870, that 30 lbs. per sq. ft. is a maximum load of a moving mass of people). Since the promenade is 15 ft. wide, the load due to this source is, per lineal foot, 750 lbs. Total moving load, per lineal foot, 2,540 lbs.

The length of the main span of the bridge, in the clear, between towers, is 1,545 ft.; hence, total moving load is 3,924,000 lbs, or 1,962 tons.

In 1892, the actual weight of the bridge superstructure was computed for the use of the Board of Experts, which was appointed to advise upon the introduction of the trolley cars upon the bridge, and it was found to be, including cables and suspenders, 5,828 tons. The additional dead load that has been added from time to time is as follows: Additional new track for bridge railway, additional hauling cables and supporting sheaves, electric feed wires

and cables, trolley arms, telegraph and telephone wires and cables, trolley tracks and mail tubes, 430 tons. Total dead weight and moving load, 8,220 tons.

To obtain the strain in the cable produced by this load, this weight must be multiplied by 1.7; the strain is thus found to be 13,974 tons. The ultimate strength of each cable is 12,300 tons; or the ultimate strength of the four cables is 49,200 tons. Divide this amount by the strain in the cable, and the factor of safety is found to be 3.52. That is to say, that the whole strain which is now 13,974 tons, must be increased by 35,226 tons to produce the strain of 49,200 tons, which is required to break the cables. Now, since the weight of the structure cannot be materially increased, the whole increase, if it comes at all, must come from the moving load; and since that is 1,962 tons, it follows that the moving load must be increased the number of times found by dividing 35,226 by 1,962 × 1.7, which is 10½, before the limit of the strength of the cables is reached.

The elastic limit of the cables is two-thirds of the breaking strain, or 49,200 × ⅔, which is 32,800 tons.

The total moving load is 1,962 tons, and this would require to be increased 5.6 times in order to strain the cables even to their elastic limit, to which point the metal of the cables may be strained without injury.

With regard to the safety of the anchorages, it is only necessary to say that during the first few years of the use of the bridge both anchorages moved forward at the top about ⅝ in., but there was no movement at the bottom. This movement was due, without doubt, to the compression or settling together of the timbers under the toe of the masonry of the anchorages. During the last eight years, this movement has been about ⅛ in. at each anchorage, so that any strains that have been brought upon them up to this time have produced no injurious effect whatever, and it is not proposed materially to increase the load on the bridge.

With regard to the eight saddles, careful measurements have been made from time to time and the results show that within a year from the time the bridge was opened to public use, they had all moved toward the river about 4 ins. In the 14 years—from 1884 to 1898—they had moved from 1 to 1¼ ins. additional. There is nothing in this movement but what is normal and proper.

In July last, when the outrageously unbalanced loading occurred, the saddles moved toward the river from ½-in. on some to 2½ ins. on others. Those which moved forward at that time are all returning to their normal positions.

With regard to the movement of elevated railroad trains on the bridge, I would say, that the original schedule upon which they were run was approved by this department, and no change has since been made without proper sanction, and every direction from this office has been cheerfully carried out.

With regard to the trolley cars, soon after they entered upon the bridge a tendency was developed to run the cars nearer together than the 102 ft. limit that had been fixed as the distance apart they should run. Without delay the attention of the executive head of the Associated Trolley Companies was called to the matter, and he at once increased the number of inspectors to five on each roadway, and that number were on duty when the buckling took place on July 29. How they came to allow the cars to run so close together as to form a continuous solid line from the point where the obstruction occurred near the Brooklyn tower, over the entire structure to the New York station, I cannot tell, unless their instructions were that they should not run closer to each other than 102 ft., and that they assumed that they might stand in solid line. Be that as it may, the bunching of the cars and the consequent buckling of the lower chord of some of the bridge trusses occurred. This did not in the slightest degree affect the strength or safety of the bridge.

In order absolutely to prevent the recurrence of such a condition of loading on the bridge, instructions were at once given to the inspectors that the cars were not to be allowed to approach each other nearer than 102 ft. In addition, upon your request, the policemen were instructed by the Police Department to aid in enforcing the rule for the trolley cars, and also to prevent bunching of teams on the bridge in case of blockades. I have not the slightest fear that any serious unbalancing of the loads on the bridge will hereafter occur.

In conclusion I beg to say that in my judgment, the bridge is as safe to-day as it ever was, and that is equivalent to saying that it is absolutely safe; that no one need entertain for a moment any fears of its stability. The most careful inspection and supervision by this department of everything pertaining to the bridge has never been relaxed and will not be.

COST OF ASPHALT STREET PAVING IN LOUISVILLE, KY

At the request of the Louisville Board of Trade, Mr. J. H. Pearson, formerly City Engineer of Louisville, recently read before the Board a paper on street paving in that city, in which he pointed out the difference between the lake and the rock asphalt included in bids lately presented for paving. He argued that the two types of asphalt require different treatment to obtain the best results in each case; that climatic conditions must be carefully studied, and that it is folly for a city to apply the same specifications to both classes of asphalt paving. Incidentally he remarks that Louisville has received the lowest bids for asphalt paving of any city in the country; or $15 for a "square" of 100 sq. ft. with a five-year guarantee, and $17.76 with a ten-year guarantee. For original construction, where contractors have to collect from property owners, the bids are higher; or $16.50 and $19.50 per unit square. The portion of the report relating to the detailed cost of asphalt paving contains some useful information, and we reprint in full, as follows:

I base these figures upon the requirements of our present specifications, and take the lake asphalt streets as the example, because I, as yet, have had no means of knowing the cost of the other kind. I should judge, however, that the labor part of the construction of rock asphalt streets, as here constructed, has certainly been more expensive than the corresponding work in lake asphalt streets, judging from the number of laborers employed on each kind.

Our specifications call for an asphaltic cement for lake asphalt streets composed of standard asphalt, 100 parts by weight, and petroleum residue (average) 17 parts by weight. This asphaltic cement must be mixed with sand and limestone powder in the following proportion:

Asphaltic cement (minimum)	14 parts.
Sand (minimum)	81 "
Limestone powder (minimum)	5 "

Figuring this it means:

Refined asphaltum	12 per cent.
Petroleum residue	2 " "
Sand	81 " "
Limestone dust	5 " "

In these proportions a cubic yard of the paving materials contain:

Refined asphaltum	3.24 cu. ft.
Petroleum residue	.54 "
Sand	21.87 "
Limestone	1.35 "
Total	27 cu. ft.
	Or 1 cu. yd.

The wearing surface is required to be 2½ ins. thick. Therefore this cubic yard will cover 129.6 sq. ft. of surface, equal to 1.296 squares of surface as we measure, using 100 sq. ft. as one square. Make a note, that for this over one and a quarter squares of surface only 3.24 cu. ft. of refined asphalt is required, while the other 23.76 cu. ft. are all home products. One square of asphalt street work with us means also one square of concrete base 6 ins. thick. To cover 1.296 squares of surface with concrete base 6 ins. thick requires 2.4 cu. yds. of concrete. Also one square of surface requires one square of binder 1½ ins. thick, requiring 15 cu. ft.

Assuming the contract price of one square of street to be $18, then 1.296 squares would cost $23.33 by contract. Eighteen dollars per square has been, in round numbers, about the bid for reconstruction of streets.

Concrete made with Louisville cement can be laid at a fair profit for $3 per cu. yd. Thus the 2.4 yds. required would cost $7.20, leaving $16.13 out of the $23.33 for the cost of binder and wearing surface. The 15 cu. ft. of binder, assuming broken stone to cost $1.25 per yard (the contractor usually gets this stone off the old street at a cost of only about 50 cts. per cubic yard for breaking and hauling) the cost of 15 cu. ft. of stone would be 60 cts., and the asphaltic cement at 13½ cts. ($30 per ton) per gallon, or cost for the nine gallons required, making a total cost of $1.86 for the binder. Subtracting this from the $16.13 leaves $14.27 for the cost of the wearing surface alone.

Assuming refined asphalt at $30 per ton (the price you or I would have to pay for it, but much more, I think, than the contractor pays for it for street work), is equal to 22.9 cu. ft. per ton, or $1.31 per cu. ft. It requires 34 lbs. of petroleum residue for the 1.296 squares of street worth 5¼ cts. per gallon of 8 lbs. (as the Standard Oil Company say), or 4¼ gallons, costing 22⅓ cts. This is equivalent to 40 cts. per cubic foot.

Sand at $1.08 per cubic yard equals 4 cts. per cubic foot, and limedust at 60 cts. per barrel of about 6 cu. ft. costs 10 cts. per cubic foot. The wearing surface mixture then for this 1.296 squares costs total as follows:

Asphalt, 3.24 cu. ft., at $1.31	$4.24
Petroleum residue, .54 feet, at 40c.	.21½
Sand, 21.87 feet, at 4c	.87½
Limestone powder, 1.35 feet, at 10c.	.13½
	$5.46½

Deducting this from the $14.27 remaining out of the $23.33, after allowing for cost of concrete and binder, we have $8.80 for cost of labor and profit.

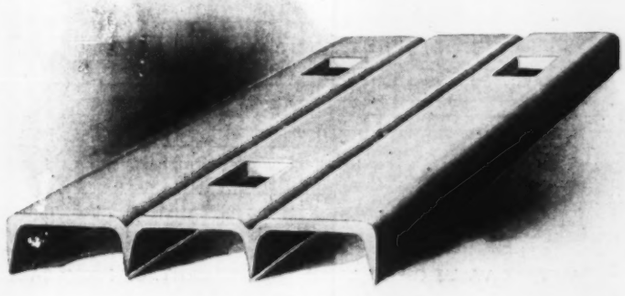
Labor is supposed to cost as follows:

Mixing	4 cts. per sq. yd.
Hauling (estimated)	2 cts. per sq. yd.
Laying	6 cts. per sq. yd.
	12 cts. per sq. yd.
	Or 1⅓ cts. per sq. ft.

The 129.6 sq. ft., therefore, costs for labor $1.73, which deducted from the $8.80 leaves $7.07 for the profit to the contractor to construct 1.296 squares of streets, which is equivalent to a profit of $5.45 per square out of the $18 per square assumed as bid or about 30%. (In these hard times a very fair profit such as few of you in your business are able to make.)

These figures show that the actual cost of lake asphalt streets is about $12.55 per square of 100 sq. ft. (there are reasons why this cost is really less, but it is very difficult to get reliable data from the companies who use it, and they are the only source for such data), and therefore, streets of this class it would seem to us taxpayers might be built cheaper than about $18 per square and still allow reasonable profit of say 15%. My own opinion, based on what I have read and learned, is that such streets can be laid without loss (perhaps no profit) at $10 or $11 per square.

As to the cost of rock asphalt streets, I think, $15 per square with a good guarantee, is about as low as we can reasonably expect good streets to be built, and I do not believe the profit is more than 10%, or possibly 15% at this price. I believe good rock asphalt streets are superior to lake asphalt streets, but not enough so to warrant discarding the latter, and they have the advantage of costing less for repairs than the lake asphalt besides having other small advantages not necessary to mention.



THE Q. & W. TIE PLATE.
Railroad Supply Co. and Q. & C. CO., Manufacturers.

A GROOVED TIE-PLATE.

A new form of tie-plate for railway track is now being introduced which combines the grooved face of the Wolhaupter plate with the outside longitudinal flanges of the Servis plate, thus effecting a combination of the strength and lightness of the former with the secure attachment to the tie of the latter. During the past two years about 40,000,000 tie-plates of these two types have been sold, each having its special advantages, and in the new plate the aim has been to include these advantages. The plates are of the form shown in the accompanying cut, and are made in two sizes, 4¼ and 5 ins. wide.

As the special features are covered by patents owned by two companies, a new company has been organized, under the name of the Q. & W. Co., of which Mr. Willis S. Jones is General Manager, with office in the Owings Building, Chicago, Ill. The sole licensees authorized to manufacture and sell the Wolhaupter, Servis and Q. & W. tie-plates, are the Railroad Supply Co. and the Q. & C. Co., both of Chicago.

WORK OF THE FIRST REGIMENT OF U. S. VOLUNTEER ENGINEERS IN PORTO RICO.

On the evening of Dec. 8 the officers of the First Regiment U. S. Volunteer Engineers gave a complimentary dinner to Colonel Eugene Griffin, the commander of the regiment, at Sherry's, New York city, and presented him with a silver loving cup.

In his speech of acknowledgment Col. Griffin described the inception and formation of the Brigade of Engineers, and particularly the First Regiment.

Col. Griffin is a graduate of West Point, in the class of '75. He entered the Corps of Engineers and afterwards resigned. At the outbreak of the war he felt that he was again called into actual service. In his position as Vice-President of the General Electric Co., in which capacity he was in close contact with the engineering profession of the country, he naturally turned towards the engineering side of the coming struggle. Mainly through his efforts, Congress authorized the formation of a Brigade of Engineers, and Col. Griffin was given command of the First Regiment. It was principally to the character and work of the men composing this regiment that his remarks referred.

In the course of his address, Col. Griffin outlined the actual engineering work performed in Porto Rico, as follows:

A detailed topographical survey of the main highway from the sea, through Ponce to Aibonito; a survey of the Aibonito Pass, showing the locations of the Spanish batteries and intrenchments; a detailed hydrographical survey of the harbors of Ponce and Guanica; the rebuilding of the fine masonry bridges destroyed by the Spaniards on the military road which crosses the island; the building of a dock and commissary storehouses; the setting up of an ice plant and refrigerating plant for the General Hospital at Ponce, and the construction of buildings for this purpose; the building of a concreted high level reservoir for the hospital, and the completion of the water supply system, including setting up the pumps, laying the pipes, etc.; the partial construction of Fort Capron on the heights overlooking the entrance to Guanica harbor, and the building of a road up the side of the mountain leading to the fort; the laying out of the first National Cemetery in Porto Rico, and many other minor works.

From the time the first detachment of recruits arrived at Peekskill, N. Y., on June 23, until the regiment returned to New York, on Nov. 24, was 154 days. The start was made with 1,097 men and 48 officers, while 857 men and 47 officers returned, 13 men and one officer died, 61 men were left in the hospitals at Ponce and Guanica, the remainder having been discharged or sent home on sick furlough at different times.

In referring to the personnel of the regiment, Col. Griffin said:

It is my deliberate judgment that engineers, including tradesmen, will make better soldiers than any other class of men, and by soldiers I mean all that the word implies, men trained in drill and marksmanship, able to care for themselves in the field, and to make long marches and to meet the enemy under all conditions, either offensively or defensively. The very nature of the training and daily lives of carpenters, blacksmiths, plumbers, lumbermen, railroad men, steam engineers, electricians, masons, etc., is a preparation for the life of the soldier.

THE CALORIFIC POWER OF COALS IN RELATION TO THEIR PROXIMATE ANALYSES.

In the discussion of the paper of Messrs. R. S. Hale and H. J. Williams, on "The Calorific Power of Weathered Coal," at the New York meeting of the American Society of Mechanical Engineers, Mr. William Kent presented a written discussion, from which we abstract the following:

The authors have compared their results with the curve which I plotted from the results of Mahler's calorimetric work, and published in Vol. I. of "Mineral Industry," in 1890, and also in 1897 in Vol. XXIV. of the Transactions of the American Institute of Mining Engineers, in connection with the discussion of Profs. Lord and Haas on American coals. This curve has frequently been referred to by recent writers, and has now fairly established its validity within the limits claimed for it. I present the curve herewith, with a slight modification which later studies have made advisable.

A table derived from the curve is as follows:

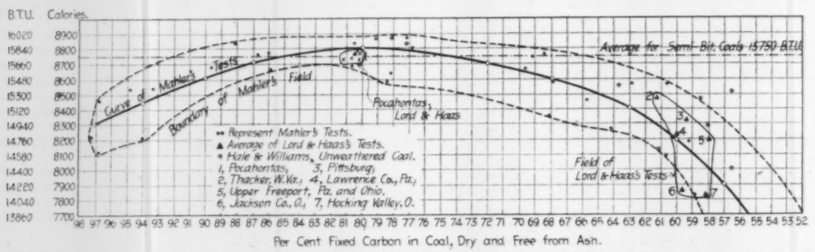
Approximate Heating Value of Coals.

Fixed carbon in coal.*	Heating value. Calories.	Heating value. B.T.U.	Fixed carbon in coal.*	Heating value. Calories.	Heating value. B.T.U.
97%	8,300	15,940	63%	8,400	15,120
94%	8,450	15,210	60%	8,200	14,760
90%	8,600	15,480	57%	7,900	14,220
87%	8,700	15,660	55%	7,700	13,860
80%	8,800	15,840	53%	7,400	13,320
72%	8,700	15,660	51%	6,900	12,420
68%	8,600	15,480			

*Dry and free from ash.

The original claim made for the curve was as follows: "Knowing the percentage of fixed carbon in the dry coal free from ash, we may, in the case of all coals containing over 58% of fixed carbon, predict their heating value within a limit of error of about 3%."

In 1897 a study of Lord and Haas's work led to the following statement: "Excluding coals which have below 58% of fixed carbon in the combustible, the variation of any one of Lord and Haas's coals from the Mahler line does not exceed 320 calories (576 B. T. U.), or about 4%. Taking the average figure for each class of coals [There were seven classes, 39 coals in all, viz.: Pocahontas, 5; Hocking Valley (O), 5; Pittsburg, 7; Middle Kittanning (Pa.), 7; Upper Freeport (Pa. and O.), 11; Mahoning (O.), 1.] it falls in all cases within the limit of 3%. Taking into consideration the fact that the reported percentage of fixed carbon is very apt to be 2% or 3% in error, I am disposed to hold my original conclusion, at least until a larger series of tests may show that it should be modified. It is to be observed, however, that the Mahler line falls rapidly with percentages below 62% of fixed carbon; and it is therefore to be expected that below this point there will be a greater range of variation in the heating value than above it. When the volatile matter exceeds 38% an increasing proportion of it is exygen; and the relative proportion of oxygen in the highly volatile coals varies in the coals of different districts, as is shown by Lord and Haas's analyses. Thus the Upper Freeport coal averages only 9.58% of oxygen (in coal dry and free from ash), while the Hocking Valley coal averages 16.10%, although both coals have the same percentage of fixed carbon, namely 58%. Full credence, therefore, is to be given to the conclusions drawn from Lord and Haas's tests that, when the fixed carbon is less than 62% of the combustible, each class of coal has a law of its own, and coals of any one class may differ in heating value from coals of another class containing the same percentage of fixed carbon to an extent as great as 5%, as in the case of the Hocking Valley and Upper Freeport coals."


B.T.U.
Calories.
Average for Semi-Bit. Coals 15750 B.T.U.
Curve of Mahler's Tests
Boundary of Mahler's Field
Pocahontas, Lord & Haas
Field of Lord & Haas's Tests
Represent Mahler's Tests.
Average of Lord & Haas's Tests.
Hale & Williams, Unweathered Coal.
1, Pocahontas, 3, Pittsburg,
2, Thacker, W.Va., 4, Lawrence Co., Pa.,
5, Upper Freeport, Pa. and Ohio.
6, Jackson Co., O., 7, Hocking Valley, O.
Per Cent Fixed Carbon in Coal, Dry and Free from Ash.

RELATION OF THE CALORIFIC VALUE OF COALS TO THE PER CENT. OF FIXED CARBON IN THE COMBUSTIBLE.

A study of the results now presented by Messrs. Hale and Williams shows:

(1) That all the calculated or calorimetric results of coals containing more than 59% of fixed carbon in the combustible, weathered or unweathered, are within the stated limit of the curve of 3%, with the single exception of the result calculated from the analysis of the weathered coal "D." This exception is evidently due to an error in the analysis. The aproximate analysis shows an increase of fixed carbon by weathering of 3.68%, referred to combustible; while the ultimate analysis shows a decrease in total carbon of 0.99%. The figures are incompatible.

(2) The coals containing less than 59% of fixed carbon show in most cases a wide divergence from the curve, tending to confirm the conclusion drawn from the work of Lord and Haas that among the highly volatile coals each class of coals has a law of its own.

SPECIAL WIRE ROPES FOR HOISTING PURPOSES.

In the ordinary construction of wire ropes a the strands are built up of wires of circular cross section, and the outer wire of each strand takes the wear in coiling and uncoiling, so that small wires are liable to be soon worn through, while heavier wires have a tendency to fracture when the wear by abrasion has reached a certain limit. In the two styles of wire rope shown herewith, each strand has a core or central wire of special form.

The strands of the "flattened strand" rope, Fig. 1, are built up of circular wires around a flattened central wire, so that the strand is approximately oval in section, and several of the outer wires take the wear and transmit the pressure to the flattened wire. In fact, the rope is said to have 150% more wearing surface than ordinary rope, thus tending to increase its life, while its greater

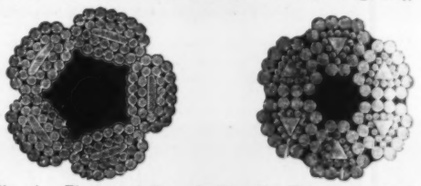


Fig. 1.—Flattened Strand Rope. Fig. 2.—Triangular Strand Rope.

Wire Ropes for Hoisting.
A. Leschen & Sons' Rope Co., Makers.

smoothness of surface reduces the wear upon the pulleys and sheaves. It is also said to be exceedingly flexible, with freedom from any tendency to spin or kink.

This style of rope is being extensively used for passenger and freight elevators in office buildings, warehouses, stores, etc. The ropes in the passenger elevators of the Decker Building, New York, have been in constant use since April, 1896, and are still in good condition, though the owner of the building states that they have already lasted twice as long as the ropes formerly used. All the elevator ropes are made of special Swedish iron wire. The ropes used for this purpose are principally ⅝-in. and ¾-in. diameter, weighing about 67 and 96 lbs. per 100 ft., and having a breaking strain of 6 and 9 tons, respectively. The same style of rope is also used for haulage and power transmission.

The "triangular strand" rope, Fig. 2, has the central wire of each strand made of triangular section, with several wires bearing upon the outer face of this wire. This rope is said to have the same advantages in smoothness and flexibility as the "flattened strand" rope. It is being extensively used for heavy hoisting in mines, on derricks and on inclines, etc., for which purposes it is made of Hercules brand wire or of crucible steel wire.

Both these ropes are manufactured by the A. Leschen & Sons Rope Co., 920 North Main St., St. Louis, Mo., and we are indebted to the makers for the above particulars.

AN ILLUSTRATION OF THE INFLUENCE OF IRRIGATION ON SOIL TEMPERATURE.*

By L. G. Carpenter and R. E. Trimble.†

The control which irrigation gives of soil conditions is well known by students of irrigation and is more or less realized by farmers in the arid regions. The extent of this influence is, however, not often recognized, and it is rarely that an illustration as clear as was shown by the soil temperature observations during August, 1897, is to be obtained. In this case our soil thermometers being placed in the grass plat were so situated that the irrigation of the lawn flooded, to a depth of some inches, the ground where the instruments were placed, and the irrigation was continued long enough to saturate the ground underneath. The temperature at a depth of 6 ft. had been nearly uniform at 62° F. for a number of weeks before the date of irrigation on Aug. 12.

With the application of the water it is noticed that the temperature immediately rises, reaching a temperature of 71° almost immediately after. The temperature fell almost immedately after the irrigation, so that during the next three days it had fallen to 64½°. On Aug. 16 the irrigation was repeated, and this time the effect of this added to the effect of the first was to increase the temperature to 75½°. The temperature dropped rapidly to 69°, and then dropped gradually, not again reaching 62° until October. The effect of irrigation on the plat of ground and its vicinity was felt for more than a month.

The effect on the temperature at 2 ft. and at 3 ft. in depth was much the same. At the first irrigation the temperature at 2 ft. was increased over that at the lower depths. At the second irrigation the effect on the deep thermometer was almost as great as upon the 2-ft. thermometer. For the depths less than 2 ft., the diurnal fluctuation is marked, and as the corresponding curves confuse the diagram, they are omitted. The shallower thermometers also show the cooling effect from evaporation

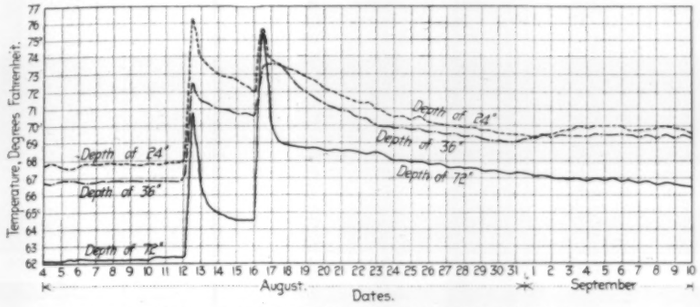
*Extract from Bulletin No. 49, "Meteorology of 1897," of the Agricultural Experiment Station, Ft. Collins, Col.
†Meteorologists and Irrigation Engineers to the Station.

so much that their temperatures fell below the deeper ones. In view of the influence which temperature has upon the growth of plants, the importance of the fact shown in the diagram is apparent. Evidently the irrigator can increase the temperature of the soil by application of water of proper temperature. It is also evident from corresponding observations at the shallower depths, that the cooling effect on the soil from evaporation may be considerable.

But as the application of water warmer than the soil will carry heat down into the soil and raise the temperature in spite of the cooling effect of evaporation, so an application of colder water has the opposite effect and chills the soil, both by the direct abstraction of heat and from evaporation.

The diagram is here given because of its suggestiveness, and to call attention to the influence of the temperature of the water used. It also suggests a reason why most farmers find it undesirable to irrigate early in the spring and why fall irrigation is sometimes so advantageous irrespective of the need of moisture.

The importance of considerations of this kind, illustrated by the diagram, will be considered more extensively when the observations on irrigation and on soil temperature are published.



THE EFFECT OF IRRIGATION ON SOIL TEMPERATURES.

MUNICIPAL OWNERSHIP OF WATER-WORKS at Winnipeg, Man., seems likely to be effected soon, it being reported that the London bondholders have accepted the offer made by the city to pay $237,500 for the plant of the Winnipeg Water-Works Co.

THE EXPIRATION OF THE TELEPHONE FRANchise of the Duluth & Superior Telephone Co., Duluth, Mich., occurs on March 9, 1898, and the city of Duluth has decided to advertise for bids for furnishing telephone service for a term of years. A percentage of gross receipts will be demanded and a rate lower than that heretofore given, together with a certain number of free instruments and a differential in favor of residence telephones. The present company is one of the Bell corporations, and this week has reduced house rates from $50 to $36 a year.

THE LOWEST BID for garbage collection and disposal at Philadelphia for the ensuing year was from the American Product Co., $358,000. The contract price for 1897 aggregated $327,100, the above company now having the contract for three districts,and treating the garbage by the Arnold process, while the Phildelphia Incinerating Co. now has the contract for the two remaining districts, and burns the garbage in Smith-Siemens furnaces. The latter company did not bid this year and there was scarcely any competition. That there was little competition is not surprising in view of the fact that the contract is for but one year, and has been divided between much the same interests for several years back.

THE NEW YORK CONTRACT FOR SNOW REMOVAL was awarded, on Dec. 9, to Bart Dunn, at 30 cts. per cu. yd., or the lowest price since the contract system was inaugurated. The bond required is $100,000. The other four bids ranged from 30⅛ to 38 cts. per cu. yd.

THE WARING FUND has now reached $77,555, the later contributions ranging from $100 down. The contributions for Dec. 9 aggregated $7,553, and the Chamber of Commerce Committee is now assured of the speedy receipt of the entire $100,000 asked for.

CREOSOTED WOOD PAVING BLOCKS 4 ins. deep, on 6 ins. of concrete, have just been recommended to the Kensington Vestry of London, by Mr. Wm. Weaver, Surveyor, according to the London "Contract Journal." It seems that some of the ratepayers were anxious to extend the use of wood paving in place of the present macadam. Under existing rules this can be done, Mr. Weaver states, only when the maintenance of the macadam road costs 20 cts. per sq. yd. per year, "without scavenging and watering." This condition prevails only under "very severe traffic." To reduce the standard of conversion without an increase in the expenditure, 4 instead of 5-in. blocks are recommended. Mr. Weaver states that the reduction of the depth of the blocks from 6 to 9 ins. to 5 ins. in 1883 has saved the Vestry about $60,000. In 1889 two streets were paved with 4-in. creosoted deal blocks, regarding which Mr. Weaver says:

After nine years wears, the road surface is in nearly perfect condition, and only a very small amount has been spent on repairs during the nine years; one-fifth of a penny per superficial yard for last year, and a half-penny per yard for the preceding year.

The road is wearing thin and the wood will have to be renewed in 1900. The traffic on these streets is very heavy, having increased on one of the streets from 1,420 vehicles, or 42 per ft. width in 1888, to 2,950, or 87 per ft. width in 1898. The wood paving cost about $2.25 per sq. yd. in 1888 and the renewal is estimated to cost about $1.70. Mr. Weaver concludes that wood paving consisting of creosoted deal blocks, 4 ins. deep, laid on 6 ins. of Portland cement concrete, might advantageously be substituted for macadam where the maintenance charges on the macadam are 12 cts. per sq. yd. The cost, including capital charges, would be slightly increased, but this would be offset by the superior character of the paving.

CRUDE OIL ON COUNTRY ROADS has been given a trial at Keokuk, Ia., with very gratifying success, according to a report presented by Major M. Meigs before the Missouri Good Roads Association on Dec. 3. The plan followed is to sprinkle ordinary dirt roads when dry, especially in low places where mud is usually formed. The oil forms a water-proof crust, keeps out the water and prevents the formation of dust and mud. It is claimed that a barrel of crude oil costing about 90 cts. is sufficient to cover a strip of road 100 × 12 ft.

A SURFACE CONTACT STREET RAILWAY of American design and construction has been recently installed at Monaco, France, by the French representative of the General Electric Co., of Schenectady, N. Y. According to the English "Railway World," this road extended from the city to the Casino at Monte Carlo, a distance of about three miles. The track, 3 ft. 3-in.-gage, is of 73-lb. girder rails, using rod cross braces and wooden sleepers. The principal grade is 1,320 ft. long, with a rise of about 1 ft. in 12. Between the tracks are two rows of studs, or contact buttons, alternating in position, which connect with automatic switches grouped together in manholes placed along the line, thus putting all operating parts where they can be inspected. On the car are storage batteries, and contact shoes that slide across the studs, operate the automatic switches and thus connect the car motors with the main feeders. The cars used are 27½ ft. over all,with a 19-ft. body. They are divided into first and second-class compartments, are equipped with G. E. 53 motors, Brill trucks, electric brakes, and other American devices.

THE GENERAL ELECTRIC CO. has obtained the contract to build eight electric locomotives and other equipment for the tunnel division of the Paris-Orleans Railway, in Paris. The contract was won against strong English and European competition. The General Electric Co., some months ago, received the contract to supply 28 similar locomotives to the new Central London Underground Railway Co.

ELECTRIC LIGHTS FOR LIGHT-HOUSES at various points on the Great Lakes will be tried by the U. S. government. It is understood that the first experiments will be conducted at Marquette, Mich., where a breakwater extends out into the lake about 3,000 ft. During storms waves frequently sweep over this making the trip to light the ordinary oil lamp extremely dangerous. The plan to be adopted includes the placing of a submarine cable along the top of the masonry, and the use of a 50-c. p. stereopticon incandescent lamp, which will be controlled from the shore.

A UNIFORM SMALL-ARM CALIBER and cartridge is the question to be considered by a board appointed by the Secretary of War, and now in session in New York. This uniform caliber should be adopted for all small arms and machine guns used by the Army, the Navy and the Marine Corps. The report will not be made public.

TWO LARGE TRANSPORTS for the use of the Navy are asked for by Secretary of the Navy Long, in a letter to Congress requesting the insertion of this item in the Naval Appropriation bill. The vessels called for would be twin-screw, steel ships, of about 7,000 tons displacement, with a maximum speed of 18 knots and to cost not more than $1,250,000 each. Such a transport would carry 1,200 men and their officers, with all regimental supplies, wagon trains, ammunition, hospital stores, etc. Distilling and refrigerating apparatus would be supplied. The argument for the building of special transports is that existing merchant ships can not be properly adapted to this purpose. All horses would be transported on separate ships of the usual type. As the Army is strongly opposed to giving up the transport of troops, it is expected that this request will cause considerable controversy in Congress. Inspector-General Breckinridge, in his annual report, favors, however, the naval control of the transport service, and this is in accordance with foreign practice.

A SPECIAL FLAG for the Coast and Geodetic Survey vessels was first adopted in launching the survey vessel "Pathfinder" at Elizabethport, N. J., on Dec. 7. This flag has a blue field carrying a white circle in the center with a red triangle in this circle.

THE TENNESSEE RIVER IMPROVEMENT ASSOCIAtion held its annual convention in Chattanooga, Tenn., recently, Gen. Joe Wheeler presiding. A memorial to Congress was presented asking that a complete survey be made of the whole Tennessee River system, and especially for the 100 miles between Bridgeport and Decatur, and the section between Florence and Decatur. The most prominent work now in progress is the Colbert Shoals Canal. The memorial concludes by asking Congress to grant the $2,065,000 recommended by the officers of the Engineer Corps.

EXPRESS COMPANIES doing business in the state of New York will be placed under the supervision of the State Railroad Commission if a bill prepared by the Merchants' Association of New York is successful. A table published by the association giving comparative freight and express charges from New York city to the principal towns in the state shows that the express charges per 100 lbs. are from 2½ to 4 times the amount of the corresponding freight charges. The association fails to state that the more prompt transmission of goods by express and their free collection and delivery justifies a considerably higher charge for express than for freight. It is doubtless true, however, that express charges, especially on small weight packages over long distances, are much higher than necessary to give the companies a fair return. It is also to be remembered that the capital of express companies represents a trifling actual investment, as compared with railway companies.

"CARBOLITE," AN ALLEGED NEW CARBIDE is discussed editorially in the "Engineering and Mining Journal" of Dec. 10. It is described in the patent of Herman L. Hartenstein, as calcium-aluminum-silicon-carbide, with the formula Al_4, C_5, SiC, CaC_2. The inventor describes a process of making it by taking blast furnace slag directly from the blast furnace into a converter, impregnating it with pulverized coke by means of a gas blast, and sending a powerful current of electricity through the mass, thus producing the carbide. "The Engineering and Mining Journal" describes the chemical reactions, showing that the product would be a very poor substitute for calcium carbide in the manufacture of acetylene, and states that it is doubtful if it can be made without infringing on existing patents. It says: "The Hartenstein patents are of a kind that ought to be shunned by investors, although we understand that considerable money has already been laid out for their exploitation."

BOOK REVIEWS.

CANALISATIONS ELECTRIQUES.—Aerial Power Lines. By R. V. Picon, Engineer of Arts and Manufactures, Paris; Gauthier-Villars, Quai des Grands-Augustins 55, Paris, France. Paper; 4½ × 7⅜ ins.; pp. 172; 86 illustrations; 18 tables.

This is another volume of the "Encyclopedie Scientifique des Aide Memorie," a series of publications upon scientific subjects published under the direction of M. Leaute. It is the third of a series by the same author, all on the distribution of electricity, the first two volumes pertaining to isolated installations and central stations. This volume, as stated in the title, treats of what may best be described as line construction, and, as would be expected, considers conductors, wires and cables; insulators for low and high potentials; insulator pins, brackets, cross-arms; poles, anchorages, metal poles and the other line materials.

The book is divided into four parts, Line Materials, Erecting the Line, and Tables and Calculations, which headings suggest in a general way the contents. No at-

tempt is made to exhaustively treat the subject, but enough is given to make the book interesting and instructive reading.

DIFFERENTIAL AND INTEGRAL CALCULUS FOR TECHNICAL SCHOOLS AND COLLEGES.—By P. A. Lambert, M. A., Assistant Professor of Mathematics, Lehigh University. The Macmillan Co., New York and London. Cloth; 12mo.; $1.50.

Of the making of books on calculus there is no end. The present work may be useful to a teacher of mathematics to have in his desk as a reference book along with a dozen other works on the same subject, but we think few teachers would care to substitute it as a class book for the one they have been using. The author uses the method of limits instead of the infinitesimal method, and his discussion of limits is far from being as clear as that of some other writers. His style is in general too concise for clearness. The book contains a great number of problems, but there seems to be no good reason why the answers to these problems should not be given.

DAS WASSERWESEN DER NIEDERLANDISCHEN PROVINZ ZEELAND.—Von Friedrich Müller, Königlisher Regierungs-Baumeister. Mit 10 Tafeln in Steindruck, enthaltend 133 abbildungen, sowie 121 abbildungen im text. Berlin, 1898, Wilhelm Ernst & Sohn. Boards; 10½ × 7 ins.; pp. 612, and atlas of ten plans, 11⅝ × 10¼ ins. 36 marks.

This is an exhaustive study of the proposed and actual reclamation of the Province of Zeeland, in the Netherlands, including the region covered by the mouth of the River Schelde. The author begins with the geological formation and traces the processes which have resulted in the peculiar configuration of this part of Holland; he traces the elevation of the "polders" reclaimed from the sea by dykes, and by reproductions of old maps, dating back to the 6th century, he shows the successive encroachments of the sea and the efforts made to beat it back, as nearly as the somewhat uncertain mapping of these centuries will permit. Views of old towns and cities, taken at different periods, show their gradual destruction by the sea, or their apparent removal from the sea coast by sand accumulation. Modern reclamation work is then taken up in detail showing mattrass protection, fascines, dyke-building with piles and stone, tools used, etc. The sand-dunes and the beach are separately treated, and the means described for stopping the advance of the one and arresting the destruction of the other The cost of work of this character is given at very considerable length, and the several systems adopted are compared. Pier and breakwater building follow, and individual examples are fully illustrated and described. A chapter is devoted to the organization, personnel and regulations of the Waterstaat, or department of the government having this work in charge; the duties of the engineer and other officials are defined, and the adopted program is laid down for the several sections of Zeeland and the methods indicated by which the work is to be carried on. The construction of ship canals and the maintenance of communication with the sea, for the important towns, conclude the volume. Mr. Müller's work is both a treatise on the natural conditions existing in Zeeland, and a hand-book of methods adapted for dealing with them.

SEWERAGE; THE DESIGNING, CONSTRUCTION AND MAINTENANCE OF SEWERAGE SYSTEMS.—By A. Prescott Folwell, M. Am. Soc. C. E. New York: John Wiley & Sons. London: Chapman & Hall. Limited. Cloth; 6 × 9 ins.; pp. 372; 24 tables and 48 illustrations. Price, $3.

A book on both the separate and combined systems of sewerage, based on recent American practice, and noting the most instructive features of foreign work, has long been demanded in this country. This volume goes far towards filling the conditions named, as far, probably, as could be expected within the limits of 350 pages. More extended treatment at some points would be welcome to many, but most of the information the author might have added can be obtained elsewhere. Thus, only an outline of the principles involved and the methods available are given under sewage disposal by other methods than dilution, the author stating in effect that a full presentation of the subject would double the size of the volume, besides going over ground already "most ably treated by others." This is an extreme example, however, as most of the other phases of sewerage engineering are presented with sufficient fullness to enable an engineer not familiar with sewerage design and construction to solve all the ordinary and many of the special problems that arise in practice. For the most part, the author could have gone into the subject more fully only by giving more of the data on which his conclusions are based and more examples of actual practice in the design of sewerage systems. Sewage pumping machinery might have been given more space than five pages with great advantage. It is true that pumping is not often necessary, and that reference may be had to several books on pumping engines, but pumps must be used much more frequently in the future than in the past, and if the student is to be referred to other books on this subject, so he might be for some of the facts regarding the hydraulics of sewers, though with less propriety, we admit. Certainly it seems a pity that the reader cannot learn from the book what sort of a device a Shone ejector is, except by inference from its name and the statement that compressed air is used to operate it. One reading about the device for the first time would like to know how it works.

Under sewer assessments, reference, at least by title, might well have been made to the Brockton report on this subject and to the symposium recently published in the "Journal of the Association of Engineering Societies," two valuable sources of information.

The volume is divided into three parts: (1) "Designing"; (2) "Construction"; (3) "Maintenance." The last two divisions are intended to be practical, as they should be, and they are very satisfactory in this respect. They give the impression of having been written by a person recently connected with actual works, who has at the same time noted the experience of others. The accompanying sketches aid greatly in giving a clear idea of the methods described.

Regarding the book as a whole, it may be said that it is a comprehensive presentation of the subject, well up to date, written in a clear, logical and attractive style. Two praiseworthy features noted at various points are good judgment in weighing evidence and an absence of crotchets and hobbies. We are glad to see that the book has an index, and one that is well above the average.

TRAITE PRATIQUE DE LA CONSTRUCTION DES EGOUTS. Jules Hervieu. Paris, 1897: Baudry et Cie.

The title of this book is misleading, for it is essentially with the sewers of Paris that the author deals. But concerning these, he goes into considerable detail, stating briefly the underlying principles of their design, but avoiding long mathematical discussions or, indeed, any great elaboration of the principles involved in the general design of sewerage systems. From the title one would look for something more comprehensive in scope. Nevertheless, the volume is well worth the perusal of American engineers, for it contains the results of the accumulated experience of a corps of highly trained municipal engineers for some half a century. The book is divided into two parts, the first treating of the general design of sewers and accessory works, and the second describing their construction and giving estimates of cost. There are, moreover, sixteen appendices, which contain, among other things, samples of specifications, time books, etc., standard sections of the Paris sewers, details of the calculation of quantities, and a discussion of run-off.

The American reader will note the care with which provision is made for what many are apt to consider unimportant features of such work—matter which our city officials are accustomed to leave to the caprice (or, perhaps, the good sense) of the party in control. The following are a few of the many particulars in which the practice in Paris is seen to differ from that in this country: First, as to design, dead ends are generally avoided and where two sewers cross at different levels steps connect the two for the convenience of the workmen. The use of pipe sewers is limited to a comparatively small number of unimportant laterals, most sewers being built of stone of the well known sections with cunette and banquette. They are sufficiently large to carry water and compressed air pipes, electric conduits, etc., as well as to permit cleaning by manual labor without inconvenience. Vassy cement appears to be quite generally used except for a coating of Portland cement plaster, from 1 to 3 cm. in thickness, applied to the interior surfaces. The extrados of the arch receives a coat of Vassy cement mortar, 2 cm. in thickness. This, being "particularly exposed to injury by street urchins who frequent the works after the workmen leave, it is well to stop work some hours before the end of the day, so that the mortar may then, having acquired sufficient consistence, be covered by a protecting layer of earth at least 0.4 to 0.5-m. in thickness" At least fifteen days before beginning the work, notice is served, the Prefect of Police making known its nature and location, and indicating the proper route to be taken by street traffic during construction. "After obtaining authority to close the street, individual letters are addressed by the engineer of the municipal service to each abutting property-holder, advising him of the dates of the beginning and termination of the work; this notice is to allow those interested, especially manufacturers and tradesmen, to make every necessary provision in time to avoid the sudden interruption of traffic."

Attention is being directed more and more to the loose way in which many American cities have virtually abandoned the control of their most valuable streets by the award of franchises to electric light and other corporations; and it is therefore of particular interest to note that in Paris subways and other structures, the use of which is permitted to concessionaires, are not allowed in any way to hamper the city in the construction of its sewers.

During the process of excavation compressed air or other pipes, controlled by concessionaires, which interfere with the work, are removed and subsequently replaced by the latter without charge to the city, on the grounds of public necessity. It is provided, also, that when articles of value, coin, medals, etc., are found on the work, they shall become the property of the administration, but that the finder shall receive as a reward one-half the value thereof. What proportion of such articles of value fail to reach the coffers of the administration is not stated. It is customary in some American cities, in order to avoid unbalanced bids, to fix unit prices for certain classes of work or material, the amount of which is a matter of particular uncertainty. In Paris, probably for the same reason, the city assumes the cost of pumping required to drain the trench. "As long as the depth of water at the bottom of the excavation does not exceed 10 cm. the contractor shall, without further allowance, drain the water to the pumps, the cost of pumping remaining solely as a charge against the Administration; the works required to ensure drainage when the depth exceeds 10 cm., rests, on the contrary, entirely at the expense of the administration." In the construction of arches of small diameter, two half centers abutting at the crown are used. They are supported by props, and in this way "put" holes in the masonry are avoided. In exceptional cases, gas pipes are permitted to cross through the sewer arch, but cast-iron sleeves are then provided, which completely encase the portion of gas pipes so included.

Particular care is given both in the design and execution of the work to afford every convenience and safeguard to the laborer. "When the excavated earth is infected or polluted by excrementitious matter or infiltrations which are liable to endanger the public health, or even to alarm the inhabitants of the neighborhood, the contractor shall proceed, at his own expense, to sprinkle and disinfect such earth and the sides of the trench with antiseptic agents. Among the latter most commonly employed are a saturated solution of the sulphate of iron and milk of lime freshly prepared according to the formula indicated in the prophylactic instructions in use for contagious diseases." After further instructions regarding the disposal of infected material, particular directions are given to ensure the safety of workmen engaged in disinterring and removing bodies from cemeteries—these, probably, being more frequently encountered in Paris than here. Besides the use of special antiseptics, ventilating apparatus, etc., "it is well each day in the morning to serve all persons engaged permanently upon the work an allowance of coffee and rum, as customary in Paris in the municipal service of disinfection. During the day the workmen should use exclusively as a beverage drinking water to which has been added a small proportion of coffee and a few drops of rum; it is not necessary to conceal the fact that this hygienic prescription will always be found difficult of application." (The author does not state whether or not the difficulty lies in securing the prescribed proportions of ingredients.) Indeed, the merits of rum appear to be well recognized in the municipal pharmacopœia, for it is further recommended that, to persons exhibiting symptoms of gastric trouble, or those afflicted with colic or diarrhœa, a small glass of rum, with essence of mint, laudanum and water be immediately administered.

Nor is the workman employed on maintenance neglected. Instead of groping his way down a contracted manhole containing a few straggling pieces of iron called steps, he enters an ample manhole on the sidewalk, the side furnished with steps which are vertical, instead of having an inconvenient "negative batter." A few steps bring him to a gallery which leads by a gentle slope to the sewer. The latter has a footway provided on one or both sides of the channel, and, where a gradient of over 3% obtains, not only are there steps to prevent slipping, but a handrail at the side and a gate (barre-de-surete) or chain at the upper end are provided to prevent accident by a misstep. In the meantime a simple contrivance holds the manhole cover propped up, if desired. There are, moreover, other manholes built directly over the sewer and without steps, solely for the purpose of dumping snow into the sewer in winter. This, of course, saves considerable expense in haulage. Flushing tanks, or reservoirs, have been largely introduced of late years. From 1881 to 1894, 2 274 of them were installed. They are frequently built in two compartments, one containing an automatic syphon and the other a valve for hand-flushing.

In measuring up the work, distances are always computed on the slope and, wherever possible, measured inside the sewer itself, instead of on the surface. The price paid per meter assumes a fill above the extrados of the arch of one-half a meter and a proper allowance or deduction per cm. excess or deficit, as the case may be, is made. A similar rule holds good where the work is laid on a foundation of masonry, the unit price assuming a uniform thickness of the latter of one-half of a meter.

From the above random notes, it will be seen that the methods of sewer design and construction are reduced in Paris to a very precise system—cut and dried, it would seem, to meet all ordinary contingencies. Formulæ, elements of design, wages, and, in fact, all possible details are, so far as practicable, permanently established; and in this way considerable subsequent litigation is no doubt avoided. And while there is much that would not bear transplanting to this country—as, for instance, the excessive number of fixed regulations concerning trivial matters which might safely be left to an intelligent resident engineer—yet, there remains much for us to profit by in the observation of methods which have been thought out and applied with so much care abroad. The chapter containing an account of shield tunneling is especially well written, and particularly interesting as a process employed with such marked success under adverse circumstances on the Clichy Collector and from its recent adoption for the 39th St. intercepting sewer in Chicago. The book is generally clear and concise in style and contains many illustrations; moreover being printed in good open type on good paper, it makes an attractive volume. Two errors may be noted: On page 55 line 15 from top, in place of C insert D; and in Fig. 199, the surface of the subterranean sheet of water should be convexed upwards near the wells as midway between them.